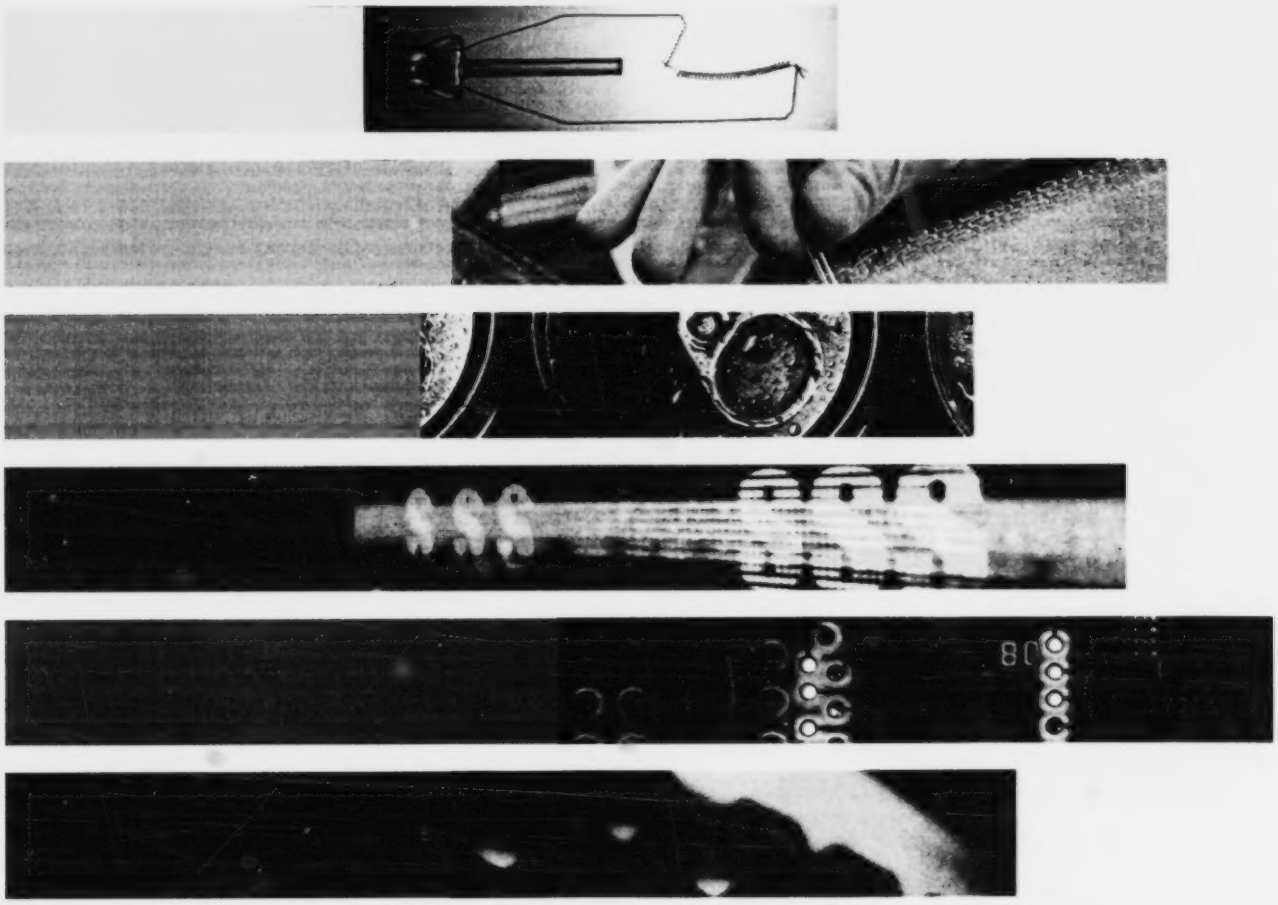
ONTARIO
Innovation 2002 INDEX
EXECUTIVE SUMMARY



Ontario

ONTARIO SCIENCE & INNOVATION COUNCIL
CONSEIL ONTARIEN DES SCIENCES ET DE L'INNOVATION

EXECUTIVE SUMMARY

The Ontario Innovation Index is the first of what the Ontario Science and Innovation Council hopes will become a periodic exercise to measure the province's transition to a knowledge-based economy. The purpose of the Ontario Innovation Index is to show how well Ontario is performing in comparison with other key provinces and U.S. states and to identify areas where improvement is needed. This first Innovation Index should be seen as a work in progress. Suggestions for improvement are most welcome.

The report employs 30 indicators to measure all aspects of the province's innovation system. The measures range from indicators of community awareness and support for science, technology and innovation through to levels of investment in the science and technology infrastructure. There are also indicators of the efficiency of the innovation process that attempt to determine whether the investments in science and technology made by all players in the innovation system are resulting in positive outcomes in the areas of knowledge generation, diffusion, and commercialization. Finally, there are indicators that explore the linkage between innovative performance and economic and quality-of-life outcomes.

Overall, the Index shows, according to a wide range of indicators, that Ontario is performing reasonably well. But in some areas, particularly education and training, there is room for additional progress if Ontario is to succeed in the knowledge-based economy, where innovation is the key to competitiveness.

What follows is a brief summary of the results from each of the main sections of the report:

1. Community Awareness and Support for Science, Technology and Innovation

The opportunities available for Ontarians to learn about science and technology issues in general have improved in recent years, thanks to increased coverage of science and technology in the media. Ontario students have also improved their performance in recent international tests of science competency, though these results still trail behind those achieved in other provinces. This is one area where there is a need for improvement.

Moreover, enrollment levels in optional science courses at the high-school level have remained relatively flat, which points to the need to find better ways to attract student interest and participation through new teaching methods and improved support for science and mathematics teachers from the primary grades onwards. There is also a looming shortage of subject-qualified teachers in the sciences that must be confronted. The Ontario College of Teachers estimates that by 2010, nearly 5,000 Ontario teachers qualified to teach mathematics, physics, chemistry, and biology will retire.

2. Science and Technology Infrastructure

The science and technology infrastructure encompasses the basic inputs into the innovation system. Are we producing the right type and quantity of skilled workers for a knowledge-based economy? Are our investments in research and development sufficient? Are Ontarians adopting information-based technologies at a sufficient rate? And does our investment infrastructure generate the funds necessary to support the development of new, innovative products, processes and services?

The Ontario workforce is highly skilled. Compared to the other major provinces, Ontario has the highest percentage of its population holding bachelors' and masters' degrees, though we do lag in the area of trade certificates and diplomas.

When it comes to producing science and engineering graduates, the picture is somewhat mixed. Of the 54,000 graduates who received a bachelor's degree in 1998, just under 7,000, or 13 per cent, received that degree in engineering and applied sciences, mathematics or the physical sciences. And when compared to the other provinces, Ontario produces relatively fewer graduates in percentage terms in such fields as engineering and business. Nevertheless, the number of graduates in most fields increased over the period 1994 to 1998, though a shortage of graduates has, at least until recently, continued to trouble such fields as computer science and engineering.

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Investments in research and development are the driving force behind an innovative economy. In comparison with other Canadian provinces, Ontario performs well. Our level of R&D expenditures per capita was the highest in the country in 1999. And our ratio of R&D expenditures to provincial gross domestic product of 2 per cent was second only to Quebec. However, using this same measure of R&D expenditures as a percentage of gross domestic product, we find that Ontario is a relative under-performer when compared to jurisdictions such as California, Massachusetts and Michigan.

When it comes to use of the Internet, we find that Ontario households are just as connected as other leading jurisdictions in North America.

In terms of the investment infrastructure available for science, technology and innovation, we find that Ontario not only leads the rest of Canada in terms of the availability of venture capital, but is also among the venture capital leaders in the Great Lakes region. Ontario's venture capital markets also held up better than comparable markets in the U.S. during the market downturn of 2001, allowing Ontario to close the gap somewhat. Nevertheless, on a per capita basis, venture capital investments in Ontario still trail far behind such leading U.S. jurisdictions as Massachusetts and California.

Investments in machinery and equipment represent another way in which firms can improve their level of productivity and innovative performance by acquiring, and successfully incorporating, new technologies and processes developed elsewhere into their operation. Ontario is a national leader in this regard, which helps, at least in part, to offset the province's shortcomings in the area of direct R&D expenditures.

3. Incentives for Commercialization and Growth

A sound economic and fiscal framework helps to provide the general environment in which innovative activity can flourish. On this score, Ontario is operating from a position of relative strength. Its fiscal situation has improved and taxes have been lowered. Personal and corporate income tax rates, as well capital gains taxes are now competitive with those found in other leading North American jurisdictions and continue on a downward path. The province also retains one of the most attractive R&D tax incentive regimes in the world.

4. Innovation Performance

Indicators of innovative performance attempt to measure whether knowledge developed at universities and other institutes of higher learning is transferred and used by the private sector to create new products, processes and services. At one end are measures of the supply of knowledge coming from universities. At the other end are measures of the economic dynamism of firms that help to determine whether they possess the entrepreneurial skill necessary to seize upon the opportunities being generated in the higher education and other sectors of the economy.

The results from the Index show that Ontario manufacturing firms are reasonably fast to adopt new advanced technologies, though they may be somewhat lacking in the ability to customize existing technologies or develop brand new ones. Ontario manufacturing firms have also shown themselves to be among the innovation leaders in Canada in the development of new and improved products, processes and services. They also demonstrate a willingness to collaborate with a variety of partners in order to promote innovative developments.

Ontario's research-intensive universities demonstrate solid performance in terms of both the quality and quantity of research produced. Ontario researchers are also well connected to the international scientific community, as measured by bibliometric data.

However, the Ontario innovation system seems less successful when it comes to transferring information from universities to the private sector. Though strong in the number of invention disclosures, spin-off companies and technology licenses generated, Ontario fares less well in terms of generating royalty earnings from technology licenses and in the ratio of spin-off companies to income from sponsored research.

EXECUTIVE SUMMARY

In terms of economic dynamism, the picture is mixed. Ontario reports a relatively low number of new business starts, though this may simply reflect the greater role played by large firms in the Ontario economy, as compared to some other provinces. Ontario did report promising levels of IPO activity prior to the stock market declines experienced in the last couple of years, suggesting that the province's financial environment is developing in a manner that is conducive to a prosperous innovation economy. And within Canada, Ontario has achieved solid overall levels of labour productivity performance thanks to its favourable industrial mix and the level of productive efficiency achieved in individual sectors. Continued investments in innovation and technology will be needed to sustain labour productivity growth in the future.

5. Innovation Outcomes

Investments in science and technology—to the extent that they contribute to innovation, enhance productivity, and lead to the development of new products, processes and services—will lead to increasing levels of economic growth. Increasing economic growth in turn means higher levels of exports and more and better-paying jobs. Economic growth can also make additional resources available for such quality-of-life goals as enhanced health services or increased environmental spending. A high quality-of-life in turns helps to attract cutting-edge businesses and highly skilled, creative individuals to a region.

Our indicator on employment in high-technology fields confirms that during the latter half of the 1990s, employment growth in such R&D-intensive fields as pharmaceuticals, aerospace and computer-related services did occur at a faster pace than for industry in general. These industries also tended to pay higher wages as well. Whether these trends have continued since the general downturn in the technology sector since 2001 will be a subject to be addressed when this Index is next updated.

Ontario's performance in the area of high technology exports is somewhat disappointing. Ontario comes second to Quebec in terms of the overall volume of high technology exports, even though Ontario is the largest overall exporter of all goods in the country. In part, this simply reflects the dominant role played by the auto sector in Ontario's export mix. Auto exports were not included in the definition of high-technology industries employed for this indicator. Of greater concern is Ontario's below average growth rates in those industries that were classified as high technology.

In terms of the broadest indicator of economic development, namely GDP per capita, Ontario performs well in the Canadian context, but lags significantly behind leading U.S. jurisdictions. This points to the need for investments in the new technologies and innovative processes that will improve productivity growth rates in both our mature industries and in the newly emerging growth sectors of the future.

Ontario offers its residents a quality of life that is unmatched by most other jurisdictions in the world. The province's cultural diversity makes it an attractive location for creative individuals from around the world. Crime rates are relatively low. And the quality of the natural environment is quite high. Though there are concerns in such areas as air quality, the province's performance, when compared to its Great Lakes neighbours, is still quite good. By contributing to the innovative practices that support economic growth, investments in science and technology help to generate the additional resources that can be used to enhance quality of life in all of its various dimensions.

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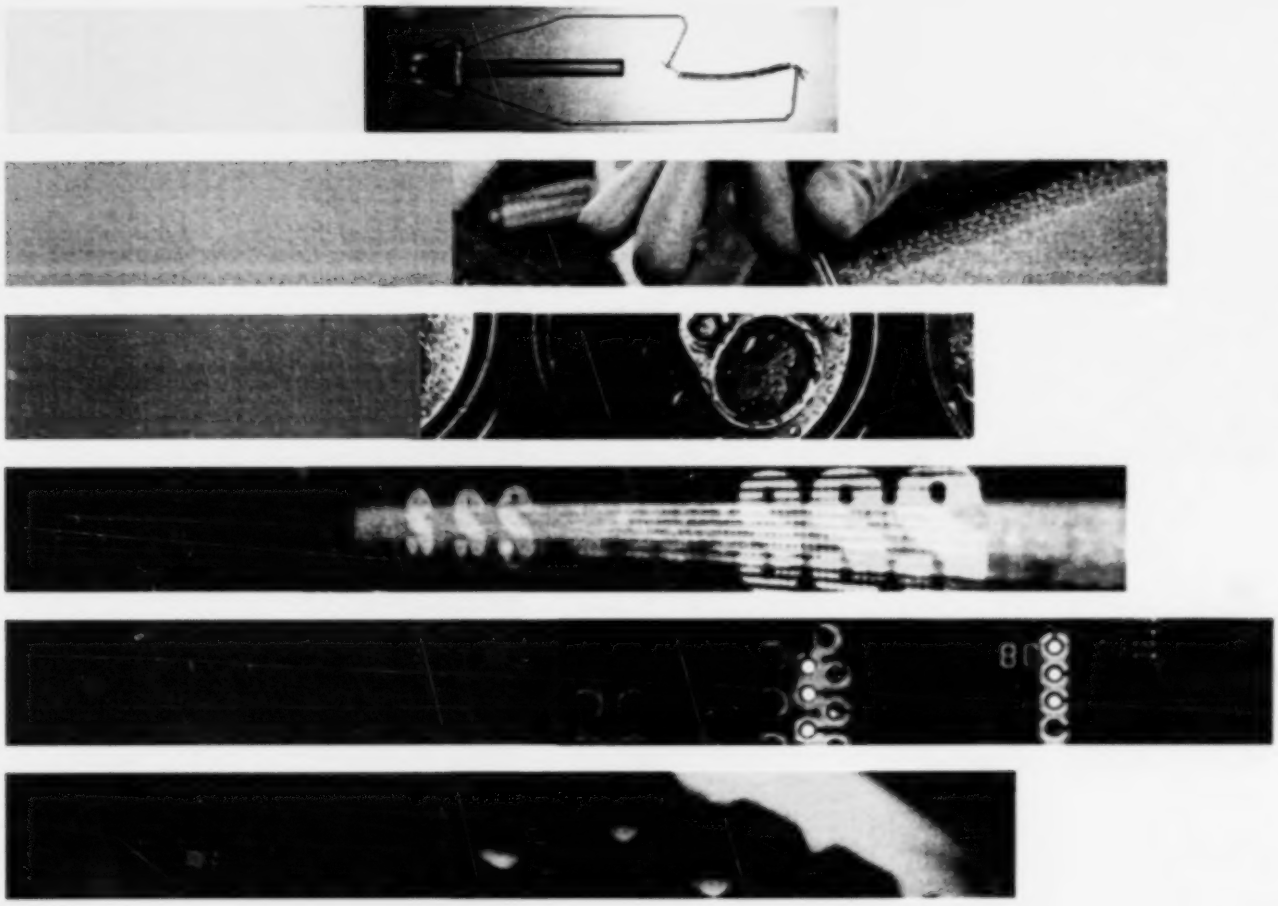

Ontario

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103-03983/

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A Report from the Ontario Science and Innovation Council

Dear Reader:

The Ontario Science and Innovation Council is pleased to present the first of what it hopes will become a periodic exercise to measure the province's transition to a knowledge-based economy. The purpose of the *Ontario Innovation Index* is to show how well Ontario is performing in comparison with other key provinces and U.S. states and to identify areas where improvement is needed.

Overall, the Index shows, according to a wide range of indicators, that Ontario is performing reasonably well. But in some areas, particularly education and training, there is room for additional progress if Ontario is to succeed in the knowledge-based economy, where innovation is the key to competitiveness.

Ontario operates from a base of strength. Its fiscal situation has improved and taxes are being reduced. Inflation is low and both short-term and long-term interest rates are conducive to investment. The availability of venture capital has much improved in recent years. Ontario is embracing the Internet and looking to the potential of electronic commerce. There has been an increase in investment in new technology by business in many different sectors.

At the same time, Ontario has introduced a number of programs, notably the Ontario Research and Development Challenge Fund, the Ontario Innovation Trust, the Premier's Research Excellence Awards, the Premier's Platinum Medal for Research Excellence and funding for biotechnology incubators at three centres in the province. The Ontario Centres of Excellence have been sustained, and the Institute for Competitiveness and Prosperity, the Ontario BIOCouncil and the Ontario Science and Innovation Council have been established. The Strategic Skills Program, offered through the Ministry of Enterprise, Opportunity and Innovation, and the Access to Opportunities Program (ATOP) from the Ministry of Training, Colleges and Universities are two initiatives designed to address those areas where an increased number of skilled workers will be needed as the Ontario economy becomes even more knowledge-based.

But more remains to be done. The greatest challenge is to equip the people of Ontario with the education and skills they will need to succeed as knowledge workers, starting from early years development, through primary and secondary schools, to colleges and universities, as well as skills upgrading and retraining through lifelong learning. With the aging of Ontario's population, it is more vital than ever that every individual has the opportunity to develop to his or her full potential. Ultimately, it is people who innovate and create wealth.

This is in part an issue of funding—our future economy will require increasingly higher levels of education and skills, which means that the entire education system will need to be adequately funded. But it will also require greater innovation as well, just as we seek more innovation in industry, we also need greater innovation in education and training. For example, given the lower-than-expected levels of interest by many students in science and mathematics, it is vital that we find better ways to attract student interest and participation through new teaching methods and improved support for science and mathematics teachers from primary grades onwards. (The Ontario College of Teachers estimates that by 2010, nearly 5,000 Ontario teachers qualified to teach mathematics, physics, chemistry and biology will retire.) As well, it is important that students have opportunities to become exposed to science and technology outside of the classroom walls—through, for example, science awareness initiatives.

The need for highly qualified people is vital, as well, if Ontario is to continue to develop as a more research-intensive economy able to develop and commercialize new ideas. Ontario will be limited in its capacity to develop and commercialize new knowledge unless it has a larger number of postgraduate students in fields such as science, mathematics and business. Yet, especially in science and mathematics, the proportion of students pursuing postgraduate studies is well below the levels that will be needed to support a more innovative and research-intensive economy.

This challenge will be compounded by the fact that the United States will also face a shortage of highly qualified people and will likely be recruiting even more intensively in Ontario—both for its industry and for faculty for its universities. Moreover, Ontario faces a wave of retirements this decade as the leading edge of the Baby Boom begins to retire.

Ontario's success in commercializing new ideas will also depend on a more effective capacity for commercialization in our universities and colleges, including the capacity to finance proof of concept and prototyping, as well as initiatives to expand the supply of angel and seed financing to innovators across the province.

Innovation has driven Ontario's economic progress in past decades, in industries such as automobile manufacturing, machinery, telecommunications technology, software, electronics, plastics, metals, finance, media and entertainment and pharmaceuticals. It is now driving our economic potential in biotechnology, nanotechnology and new sustainable energy technologies, such as fuel cells. This is critical to our future standard of living.

Innovation leading to the production of higher value goods and services, or the application of knowledge and technology to build new systems of production and delivery, is the fundamental source of sustained gains in productivity. It is through sustained gains in productivity that Ontario will generate the wealth for a higher standard of living.

As competitiveness expert Michael Porter has put it, "the future agenda is increasingly becoming one of enhancing the capacity for innovation—how to create an environment in a country, state or region that supports the creation and commercialization of new ideas. Gains in productivity from overseas pool policies and emulating best practices from elsewhere produce major benefits, but they are largely one-time benefits. Sustained productivity growth requires the capacity to innovate."

Innovation depends not only on the graduates of an effective education system, the ability to attract talented and hard-working immigrants, the development of new ideas through research and development and their successful commercialization, a financial system that enables risk-taking, investment in advanced technology and modern infrastructure but, as well, a strong culture of innovation. Innovation is about more than science and technology, important though these are. It is also about more than the policies of governments. A culture of innovation is important in our schools, universities and colleges, in our businesses and the financial community. Innovation in institutional arrangements is just as important as innovation through science and technology.

It includes the way businesses and workplaces are organized, the development of networks, strategic alliances and joint ventures, how financing is arranged, new approaches to marketing and distribution, the ways in which universities and businesses relate, the development of clusters, the use of the Internet for education and training, as well as e-commerce. That is why the culture of innovation is so important. It is a way of thinking in which change and experimentation are welcomed rather than resisted. The goal of innovation is to raise the well-being of all the people of Ontario.

Science and technology will play an ever more important role as global competition exists us to develop unique and high-value goods and services for global markets based on advances in knowledge. Research and development is a critical part of this process. This is why it is important that Ontario support a strong and diverse portfolio of fundamental science.

The need to embrace innovation, and for Ontario to articulate a strategy for innovation, is also of increasing importance due to the growing number of other provinces and U.S. states that are moving aggressively to develop innovation strategies for a knowledge-based economy. Ontario cannot become complacent as other jurisdictions seek to advance their competitive advantage.

The Ontario Science and Innovation Council looks forward to the reaction to this, its first *Ontario Innovation Index*, as well as to suggestions as to how it might be improved.

Respectfully,

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Study Framework

THE ONTARIO INNOVATION INDEX FRAMEWORK

This first edition of the *Ontario Innovation Index* should be seen as a work in progress. It is the result of a review of what indicators might most usefully provide guidance as to Ontario's strengths and weaknesses, balanced against what reliable data are actually available. As a result, the Index is a compromise. But it is hoped that it will be viewed as a credible first step on what will be an ongoing attempt to better understand how Ontario is doing and where we must improve. This section explains why the *Ontario Innovation Index* was launched and how it was produced.

Background

A growing number of jurisdictions in North America and elsewhere have begun to actively monitor the role of innovation in promoting economic and social development. At the same time, the World Economic Forum (WEF) and the international Institute for Management Development (IMD) produce their annual competitiveness rankings. These reports have attracted growing public attention and interest for two reasons.

First, there is a growing recognition that we are living in a time of major structural adjustment in our economies. This adjustment is a result of the profound technological changes coming from the sweeping enabling technologies generated by the information and communications technology revolution. These new technologies, which extend to biotechnology, nanotechnology and photonics, offer the prospect of major gains in productivity and hence living standards. But not every economy is an automatic winner in this new industrial revolution, so there is a growing interest, by policymakers and the public alike, in both better understanding how the process of innovation occurs and how well their own jurisdiction is doing compared to the others.

Second, various jurisdictions are pursuing a variety of policies to improve their chances for success in this new knowledge-based economy, such as increasing support for research and development, promoting clusters and encouraging the development of a venture capital industry. There is an understandable desire to see whether these policies are producing the anticipated results, and one way of conducting such an analysis is to compare one's own jurisdictions with other jurisdictions.

The pioneering jurisdictions were Silicon Valley and Massachusetts. The *Index of the Massachusetts Innovation Economy*, produced by the Massachusetts Technology Collaborative, has been particularly influential and has served as the model for measuring innovative activities in a number of other U.S. states and cities. The European Union has also produced a European Innovation Scoreboard. In Canada, British Columbia has been particularly active, with reports being produced by both the Science Council of British Columbia and B.C. Stats.

The origin of Ontario's interest can be traced back to the *Roadmap to Prosperity* report of the Ontario Jobs and Investment Board that was published in 1999. One of the five key goals outlined in the report was the promotion and development of an innovation culture in the province. The responsibility for achieving this goal was assigned to the Science and Technology Division of the newly formed Ministry of Energy, Science and Technology (now part of the Ministry of Enterprise, Opportunity and Innovation). Work began within the Ministry to develop a set of potential innovation indicators for internal use that would allow it to assess whether progress was being made toward the goal of developing a vibrant innovation culture in the province, and as well help to identify gaps or shortcomings in Ontario's innovation strategy.

In December 1999, the Ontario Science and Innovation Council (OSIC) was formed. Composed of representatives from academia and the private sector, the Council was given the responsibility of providing long-term strategic advice to the provincial government on science and technology issues. One of the first policy challenges that the Council was asked to address was whether the province's increased investments in science and technology were paying dividends in terms of new products and services and higher value-added jobs for Ontarians. At that point, it was determined that the internal work that the Ministry was doing on innovation indicators could help to address this specific task of evaluating the effectiveness of the government's investments in science and technology. It would also provide the Council with a useful base of information for making policy recommendations in other areas. Thus, the Ontario Innovation Index project was initiated. David Crane, economics editor of the *Toronto Star*, was chosen to serve as the Council's liaison person to the Ministry on this project.

The first step in the process was to review the model of the Ontario innovation system developed by the Ministry. It had developed a large list of potential indicators for measuring the various components of the innovation model. A benchmarking team was formed both to review the model and to reduce the list of indicators to a more manageable number. The benchmarking team was composed of David Crane, representatives from the Ministry, an academic representative and a representative from Statistics Canada. It also included representatives from key (science and technology) ministries in the government, including Agriculture, Food and Rural Affairs (now Agriculture and Food); Economic Development and Trade (now Enterprise, Opportunity and Innovation); Finance; Health and Long-Term Care; and Northern Development and Mines. The initial list of indicators was completed in December 2000.

A contract was then signed under which Statistics Canada would supply most of the data for the project. Following the completion of that contract in March 2001, the data were analyzed and a draft report was written and reviewed.

This report is the final product of the project. It should be noted that this is a pilot project. As such, we expect future editions to benefit from the lessons learned from this first effort.

The data in the report was current as of May 2002 when the Ontario Science and Innovation Council submitted the report to the Ministry. The Ministry plans a complete update of all of the indicators for the summer of 2003. Until then, we will continue to update individual indicators as data becomes available, with the updates appearing on the Ministry website.

The Innovation Framework

All the benchmarking exercises listed previously are based on some model of the innovation system. The *Ontario Innovation Index* project is no different.

The framework adopted for this project integrates the Ministry's strategic vision for promoting science and technology development within an Ontario adaptation of the national and regional innovation systems approaches developed for such groups as the Organization for Economic Co-operation and Development (OECD) back in the 1990s.

The model starts from the premise that it is critically important to generate community awareness and support for science, technology and innovation in order to fully develop a thriving innovation culture.

Investments in science and technology infrastructure are also critical, whether in the research and development infrastructure, the development of human and social capital, the provision of an information infrastructure or the development of a favourable climate for investment.

These investments in the science and technology infrastructure feed into an innovation process where knowledge is generated, diffused and used through the interaction of the key players in the system, including firms, participants in the science system (principally university researchers), players in other supporting institutions (such as venture capitalists) and actors from other research bodies (government and private-sector laboratories). We also cannot lose sight of the role of the marketplace and consumer acceptance of new technologies in the process as the force providing the "market pull" for science and technology development to go along with the "technology push" facilitated by investments in the science and technology infrastructure.

Other processes also affect the innovation process. Global contextual factors, such as the worldwide competition for highly qualified research personnel, can affect the efficiency of the system. Ontario government programs and policies are also key in providing the incentives for commercialization and growth, which, it is hoped, will lead to desirable outcomes from the innovation process.

If the innovation process works well, it should result in positive economic outcomes that will in turn facilitate a high quality of life in the province. Positive economic and quality of life outcomes will also hopefully reinforce community support for science, technology and innovation.

It is this framework that guided our selection of indicators as outlined in the next section.

Selecting Indicators

The benchmarking committee made an initial selection of indicators to achieve two broad objectives. The first was to identify a good balance of indicators that would cover most, if not all, of the components of the innovation assessment framework. The second objective was to select indicators that met the following four criteria:

1. The indicator is based on data from objective and reliable data sources;
2. The data are available on an ongoing basis;
3. The indicator measures fundamental aspects of the operation of the innovation system and issues of active public interest;
4. The indicator can be understood and accepted by a wide variety of audiences.

These four criteria are based on criteria originally developed for the *Index of the Massachusetts Innovation Economy* and have been widely adopted by other jurisdictions conducting similar benchmarking exercises.

For some components of the analytical framework, few, if any, long-term comparable indicators exist. This is particularly true when it comes to measuring community awareness and support for science, technology and innovation, and quality of life. Similarly, some of the cross-jurisdictional comparisons are based on information drawn from multiple sources that may not be always strictly comparable in a narrow technical sense.

In these instances, it was judged more important to include, for this first report, less than optimal indicators (as judged by the four criteria) in order to gain some sense of Ontario's performance in these areas. Future editions of the Index will attempt to improve upon these indicators through further development work. We also hope that the inclusion of these indicators will spark a constructive debate as to what constitute appropriate indicators in some of these less-well-measured aspects of the innovation system.

Benchmarking Comparisons

Selecting the jurisdictions to compare against Ontario was one of the more difficult tasks in the benchmarking exercise. The ideal comparison would include jurisdictions of similar size and economic structure. However, there are three principal difficulties. First, it may be difficult to find jurisdictions that meet these two criteria. Second, even when such jurisdictions are found, comparable data for many indicators may not exist, especially if some of those jurisdictions are located in another country. Third, there may be particularly compelling policy reasons for comparing Ontario with a particular jurisdiction, even if that jurisdiction is not similar to Ontario in size or economic structure. For example, some jurisdictions might be judged to be the "leaders" in terms of innovative activity, and therefore worth consideration for that reason.

Working within these limitations, Table 1 lists the eight jurisdictions that were selected for comparison with Ontario along with some basic data on their levels of population and gross domestic product.

Table 1: Background Information on Selected Jurisdictions

Jurisdiction	Population 2001 (millions)	Gross Domestic Product 2000 US$ (millions)
Ontario	**11.9**	**354,983**
Alberta	3.1	118,209
British Columbia	4.1	105,424
Québec	7.4	184,695
California	34.5	1,344,623
Illinois	12.5	467,284
Massachusetts	6.4	284,934
Michigan	10.0	325,384
Sweden	8.9	219,733

Note: Currency conversion factor for the Canadian provinces for 2000 was US$1 equals Can$1.21 (using purchasing power parities). Canadian provincial GDP figures from Statistics Canada; Swedish GDP and population figures from Statistics Sweden. Gross State Product (GSP) and population figures for the U.S. states are from the U.S. Commerce Dept., Bureau of Economic Analysis.

National averages for Canada and the United States were also included where possible.

The rationale for selecting these jurisdictions was as follows. In the cases of Alberta, British Columbia and Québec, there is a general policy interest in comparing Ontario's performance with that of the most populous provinces. In addition, we have better comparable information on more indicators for these provinces than for the other jurisdictions. Among the U.S. states, Michigan and Illinois are of interest because they are Great Lakes states and because they are similar in size and economic structure to Ontario. Massachusetts and California are included as examples of "leading" technology jurisdictions in terms of the intensity of research and development (R&D) activities found there. Finally, Sweden is included because it is somewhat similar in size and economic structure to Ontario and because it is among the more R&D-intensive jurisdictions in the world.

Due to a lack of comparable data, not all of these jurisdictions are included for every indicator. In a few other cases, other jurisdictions are included instead. Finally, there are a few indicators, such as the indicator on the scope of science coverage in major Ontario newspapers, where only Ontario data are available.

Future Trends

The economic slowdown that began to take hold during the summer of 2001 and was exacerbated by the terrorist attacks of September 11, 2001 will likely have a significant negative impact upon a number of the trends described in this report. These impacts are likely to persist for some time.

The principal impact will be the area of private-sector investments in the innovative economy. The impressive rates of increase in investments in machinery and equipment for sectors such as information and cultural industries and professional, scientific and technical services (Indicator #11) are likely not sustainable in the short term. The collapse in technology markets in 2001 will likely also lead to a slowdown in initial public offerings (Indicator #21) and venture capital financings (Indicator #10). In the long term, however, growth in all of these areas should continue to be strong.

Growth in productivity levels (Indicator #22) may also fluctuate in response to changes in the U.S. economy and the increased transaction costs that firms may confront as they deal with tightened security requirements at the U.S. border. This will also likely lead to a reduction in high-technology exports (Indicator #25).

The layoffs announced during 2001 in the information and telecommunications sector will help to reduce the skill shortages in some high-technology fields, though this will likely be a short-lived phenomenon (Indicator #23).

Some of these negative impacts will be offset by the continuing reductions in personal and corporate income taxes and capital gains tax rates (Indicator #12). The attractiveness of Ontario's R&D tax incentive structure, as measured by the B-Index methodology (Indicator #13) has also likely improved somewhat since 1998, when that information was last updated.

In the final analysis, the impact of the economic slowdown will largely depend upon the actions of individual firms. If they adopt an attitude of retrenchment, then expenditures on research and innovation will likely be significantly reduced. Alternatively, if they adopt a proactive stance, in which they view innovation as the key to their corporate survival, then we may see renewed investments in advanced technology (Indicator #14) and an enhanced commitment to innovative practice (Indicator #15). Through effective partnerships among government, the private sector and the higher-education sector, we may enhance the chances of realizing the latter outcome.

Final Comments

We welcome any comments you may have about any aspect of the report, including the structure of the innovation model, the selection of indicators (or suggestions for alternative measures) and the interpretation of the data. You can contact us by fax, e-mail or regular mail at the following:

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Innovation Assessment Model

*Adapted from a similar diagram prepared by the HAL Corporation, January 2000

Acknowledgements

A project of this scope cannot be completed without the support of others. The Ontario Science and Innovation Council and the Ministry of Enterprise, Opportunity and Innovation would like to acknowledge the support and assistance provided by the following individuals and groups:

First and foremost, we would like to thank Statistics Canada for providing us with most of the data used in this report, for reviewing earlier drafts of the indicators and for participating in the benchmarking team that crafted the initial list of indicators for inclusion in this report. We would especially like to thank the staff of the Science, Innovation and Electronic Information Division under Dr. Fred Gault for their support. Without their assistance this project would truly not have been possible.

We would also like to thank those staff from the following Ontario government ministries who also supported us by supplying data and reviewing indicators, or by participating in the benchmarking team:

- Ministry of Education
- Ministry of the Environment
- Ministry of Finance
- Ministry of Health and Long-Term Care
- Ministry of Northern Development and Mines
- Ministry of Training, Colleges and Universities

Professor Meric Gertler of the Department of Geography, University of Toronto, provided valuable advice as a member of the benchmarking team. Useful guidance on some of the individual indicators also came from Professor Benoit Godin and Christian Doré of the Observatoire des sciences et des technologies, and Steve Miller from B.C. Stats.

We would like to thank Mary Macdonald, of Macdonald and Associates, for supplying data for, and commenting on, our venture capital indicator.

We would also like to thank the staff of the Massachusetts Technology Collaborative for providing us with some very useful guidance regarding some of the theoretical and practical challenges involved in creating a report such as this.

Finally, we would like to thank Hickling Arthurs Low (HAL) Corporation for its assistance and guidance in establishing a preliminary set of indicators that proved valuable in developing this report.

As always, any errors or omissions are the responsibility of the authors of the report.

Abbreviations

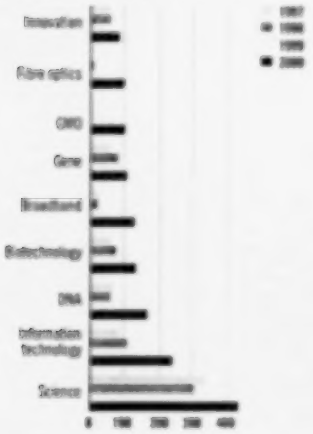
Abbreviations Used in this Report

AAQC:	Ambient Air Quality Criteria (Ontario)
AB:	Alberta
BC:	British Columbia
CA:	California
CAN:	Canada
CANSIM:	Canadian Socio-Economic Information and Management Database
CO:	Carbon monoxide
GDP:	Gross Domestic Product
GERD:	Gross Expenditures on Research and Development
GSP:	Gross State Product
IL:	Illinois
MA:	Massachusetts
MI:	Michigan
NAAQS:	National Ambient Air Quality Standards (U.S.)
NO_2:	Nitrogen dioxide
ON:	Ontario
PGDP:	Provincial Gross Domestic Product
PM_{10}:	Particulate matter less than 10 microns
QC:	Québec
SO_2:	Sulphur Dioxide
SW:	Sweden
ug/m^3:	Micrograms (of contaminant) per cubic metre (of air)

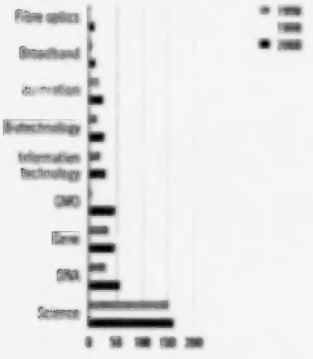
Community Awareness and Support for Science, Technology and Innovation

1. Coverage of Science and Technology in the Press

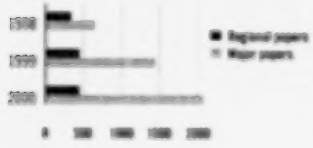
Awareness of Science-Related Key Words in Major Ontario Newspapers, 1997-2000
Average Number of Citations



Appearance of Science-Related Key Words in Ontario Regional Newspapers, 1998-2000
Average Number of Citations



Appearance of the Key Word "Technology" in Major and Regional Ontario Newspapers, 1998-2000
Average Number of Citations



Why is this important?

Newspapers represent one key source of science information for the general public. By expanding their coverage of science issues, newspapers can help to increase the overall level of science awareness among the public at large.

How is Ontario performing?

Key word counts were compiled for a series of science-related terms found in the headlines and lead paragraphs of the three mass circulation daily papers in Ontario (the *Globe and Mail*, the *National Post* and the *Toronto Star*) over the period 1997-2000. Similar key word counts were compiled for three regional papers (the *Kitchener-Waterloo Record*, the *London Free Press* and the *Ottawa Citizen*) for the period 1998-2000. Average citation rates were then calculated for these two broad newspaper groupings.

For both the major dailies and the regional papers, we see a general upward trend over time in the visibility of the search terms. This is not surprising given that most of the search terms were drawn from the fields of biotechnology and information and communications technologies, areas characterized by rapid growth rates that have generated significant public interest.

Average citation rates were significantly higher in the major papers, though the size of the gap did vary significantly by key word. For example, in 2000, the term 'DNA' was cited nearly three times as often in the major papers as the regional papers. By contrast, the term 'fibre optics' appeared nearly 12 times more often in the major papers.

Terms such as 'proteomics' and 'nanotechnology' are only now beginning to enter the public consciousness. Both of these terms only began to register in the key word counts in a significant manner in 2000.

Between 1998 and 2000, general references to the term 'technology' grew by a factor of just over two times in the case of the major papers, and by just over one-and-a-half times for the regional papers.

What this trend means for Ontario

The key word approach provides a rough overview of the visibility of certain science-related topics in the press, and the methodology will need to be refined in future issues of the Index. Nevertheless, Ontario newspapers do appear to be increasing their coverage of science issues, at least in the high-visibility fields of biotechnology and information and communications technologies. The amount of coverage may begin to level off, however, as these sectors mature.

Source: Based on key word search results compiled by the Information Resource Centre, Ontario Ministry of the Environment.
The *National Post* began publication on October 27, 1998. Earliest year in this data is from the *Financial Post*.

2. Ontario Student Performance in Science

Level of achievement of Ontario Grade 8 students on the Third International Mathematics and Science Study (TIMSS) in 1999

Why is this important?

In a knowledge-based society, citizens must possess some basic level of scientific literacy. This argument holds with even greater force for the students of today who will join the workforce of tomorrow.

How is Ontario performing?

The Third International Mathematics and Science Study was carried out in 1995 with a follow-up round being conducted in 1999 as part of the TIMSS Repeat Project. The data presented here looks at the results from the 1999 study.

The first chart compares the scientific achievement scores of Ontario Grade 8 students with those from selected provinces and U.S. states. Mean scores are depicted along with the 95 per cent confidence interval for each score.[1]

Though the performance of Ontario students has improved since 1995, their levels of achievement are still lower than those reported for British Columbia, Alberta and Québec. There are, however, no statistically significant differences between the Ontario results and those of any of the U.S. states, aside from Michigan.[1]

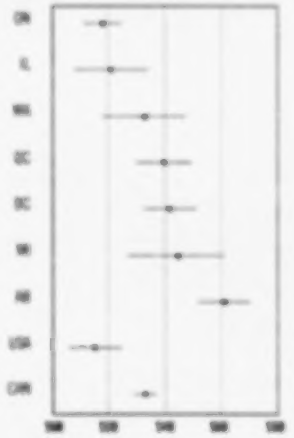
Ontario students expressed generally positive attitudes towards science with 73 per cent saying that they enjoyed learning about science. This is higher than the national average but lower than the figures reported for British Columbia or Alberta. Ontario students were less likely to say that science is an easy subject though they were more likely to say that science is important to everyone's life. Slightly less than half of the Ontario Grade 8 students said they would like a job that involved using science.

What this trend means for Ontario

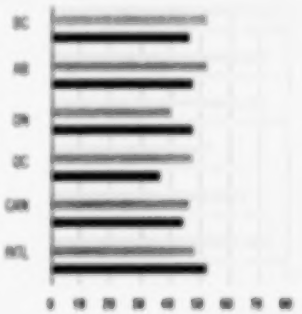
Though the overall science performance of Ontario students improved significantly between 1995 and 1999, further progress will be necessary to catch up with some of the other leading jurisdictions in Canada and elsewhere. We will also want to instill in future students the same positive attitudes toward science found among Ontario students in the TIMSS Repeat Project.

Note: An explanation of confidence intervals and statistical significance as applied to this indicator is found in Appendix A.

Grade 8 Science Scores for Selected Jurisdictions, 1999
Mean Score



Students' Attitudes Toward Science
Per Cent in Agreement



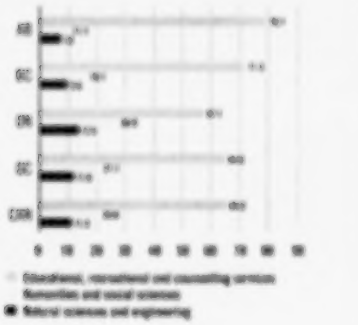
- I enjoy learning science
- Science is an easy subject
- Science is important to everyone's life
- I would like a job that involved using science

Sources: Ontario, Education Quality and Accountability Office, *Third International Mathematics and Science Study Repeat Project (TIMSS R): A Study of Grade 8 Students* (December 2000).
International Study Centre, Boston College, and the International Association for the Evaluation of Educational Achievement, *Science Benchmarking Report TIMSS 1999 Eighth Grade Achievement for U.S. States and Districts in an International Context* (April 2001).

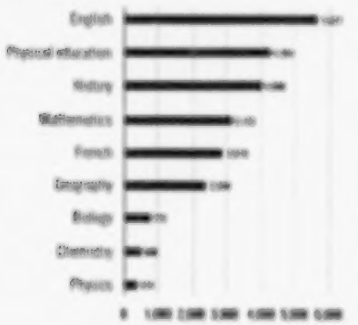
3. Percentage of Teachers with Backgrounds in Science and Technology

Field of specialization for secondary school teachers

Field of Specialization for Highest Degree, Secondary School Teachers, 1996
Per Cent



Retirements of Subject-Qualified Secondary School Teachers by 2010



Why is this important?

To ensure that our young people develop a solid understanding and appreciation of science and technology, it is important that individuals who have a firm grasp of the subject matter teach them science. Having post-secondary qualifications in science is one means by which such competencies can be developed.

How well is Ontario performing?

In the 1996 Census, respondents were asked to list the field in which they specialized for their highest post-secondary degree. In the case of most teachers, this would be their teaching degree. Unfortunately, this masks any earlier degrees an individual may have received (such as a B.Sc.) prior to attending teacher's college. Nevertheless, enough teachers listed additional higher degrees to make an analysis worthwhile.

The original 10 fields of study in the census have been grouped into three areas here: education, humanities and social sciences, and natural sciences and engineering. The specific fields making up these categories can be found in Appendix A.

A clear majority of secondary school teachers in every province list education as the field of their highest degree. But the pattern is not completely uniform. In Ontario, only 57 per cent of secondary school teachers listed education as the field of their highest degree, as compared to nearly 79 per cent in Alberta. Consequently, Ontario leads the country in the percentage of teachers with their highest degree both in the humanities and social sciences (26.9 per cent) and the natural sciences and engineering (13.5 per cent).

Though Ontario leads the country in the percentage of its secondary school teachers reporting their highest degree in the sciences and engineering, it, like the other provinces, must deal with the challenge of an emerging teacher shortage as the current cohort of teachers approaches retirement age. The Ontario College of Teachers reports that, by 2010, a total of 23,841 subject-qualified teachers are expected to retire. Twenty per cent of these retirements will occur among teachers who are qualified to teach math, physics, chemistry or biology.

What this trend means for Ontario

As noted earlier, the census is not an ideal vehicle for assessing the science background of secondary school teachers. Nevertheless, it does show that Ontario teachers are more likely to have higher degrees in the sciences and engineering than their counterparts in the other provinces. The challenge in the future will be to produce enough secondary school teachers with qualifications in science to address the looming teacher shortage.

Source: Statistics Canada, 1996 census, *Elementary-Secondary School Teachers and Others* (Ottawa: Ministry of Industry, Cat. No. 94F0035XCB, 1998). Ontario, in the mid-1990s, did not have to deal with a large number of teachers approaching the end of their careers, as most provinces needed to, and secondary qualifications: Ontario College of Teachers, "Ontario Teacher Shortage," (Toronto: February 27, 2001).

4. Enrolment in Secondary School Science Courses

Why is this important?

The impact of science and technology on our lives will almost certainly increase in this century. To successfully navigate their way in such a world, be it in terms of selecting a career or being able to understand and participate in public debates on science issues, our secondary school graduates will need to possess a high degree of science literacy and a genuine sense of curiosity about the world around them.

Though a certain number of science credits are required for graduation, we may by examining enrolment levels in "optional" science courses, gain some sense of how effective we have been in generating increased levels of knowledge and enthusiasm about science in our young people.

How well is Ontario performing?

The following data covers the period from 1996-1997 to 1999-2000, prior to implementation of the new secondary school curriculum. During this period, students were required to obtain two credits in science in order to graduate with an Ontario Secondary School Diploma. Since most students achieved this requirement by Grade 10, any science courses taken beyond that level can be effectively treated as "optional" science credits.

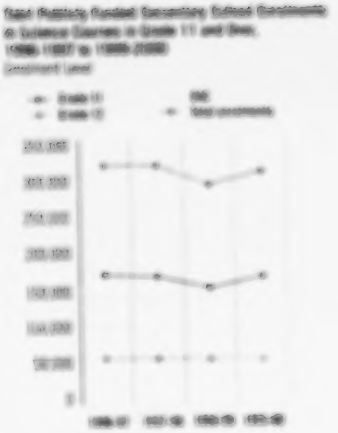
It should also be noted that the data presented represents course enrolments and not head counts, since students may have taken more than one science course in a given year from the same or a different grade level.

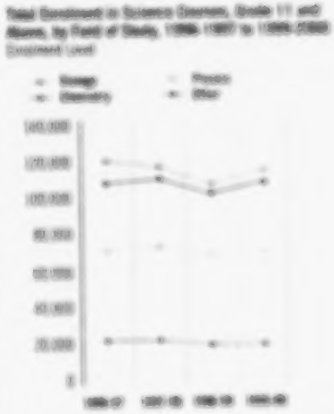
Total enrolment in all science courses in Grade 11 and above declined slightly over this period from 319,912 in 1996-1997 to 311,967 in 1999-2000. Given the small decline, this likely represents normal fluctuations in enrolment rather than a significant downward trend. The average enrolment total by grade level during this period was 164,330 for Grade 11 courses, 54,589 for Grade 12 and 93,005 for Ontario Academic Credits (OAC) courses.

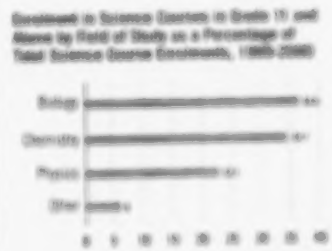
In terms of field of study, the highest enrolment level was found in biology at nearly 37 per cent of total enrolments. This was followed by chemistry at nearly 25 per cent and physics at approximately 23 per cent.

What this trend means for Ontario

Enrolments in optional-level science courses in the senior secondary school grades held fairly steady during the latter part of the 1990s. However, to address the needs of an increasingly technologically based society, it would be desirable to see an upward trend in enrolment figures. It is hoped the new secondary school curriculum, with its renewed emphasis on science and technology, will encourage such an increase.



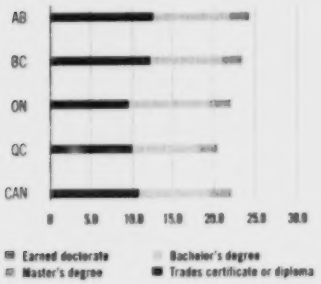




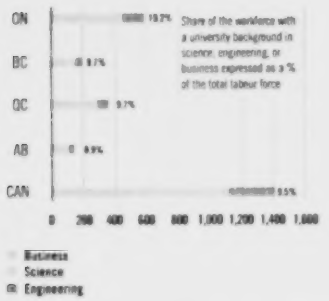
Science and Technology Infrastructure

5. Educational Attainment of the Workforce

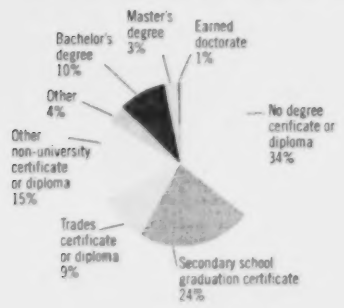
Educational Attainment
Highest Degree, Diploma or Certificate—1996 Census
Percentage of population age 15 and Over



Percentage of the Labour Force with University Backgrounds in Science, Engineering or Business, 1996
Number in thousands



Educational Attainment in Ontario—1996 Census


Master's degree 3%
Earned doctorate 1%
Bachelor's degree 10%
Other 4%
No degree cenficate or diploma 34%
Other non-university certificate or diploma 15%
Trades certificate or diploma 9%
Secondary school graduation certificate 24%

Why is this important?

Well-educated and skilled people are crucial to Ontario's innovation system, more so in the knowledge- and technology-based economy of today than at any time in the past. Indeed, the lack of such workers as engineers or entrepreneurs can prove to be one of the greatest barriers to innovation. For firms in high-technology industries seeking to relocate or expand, access to a pool of well-educated and skilled people can also be a significant attraction.

As an indicator, educational attainment is limited to the extent that it does not capture the quality of schooling, on-the-job training or the extent to which the workforce has developed such key skills as creativity and teamwork.

How is Ontario performing?

Compared to the other major provinces, Ontario has the highest percentage of its population holding Bachelors' and Masters' degrees. However, a lower number of Ontarians have trade certificates or diplomas (9.4 per cent), compared to Alberta (12.3 per cent) and British Columbia (12.0 per cent).

In 1996, 10.2 per cent of Ontario's total workforce of 5.6 million held university certificates or degrees in the sciences, engineering or business. This placed Ontario ahead of Québec and British Columbia (both at 9.7 per cent) and Alberta at 8.9 per cent. The national average was 9.5 per cent. Ontario leads the nation, though the gap in percentage terms is not large.

Of the Ontario respondents who indicated that they had a background in science, engineering or business, 33.1 per cent said that it was in business, 43.5 per cent said it was in science, and 23.4 per cent indicated engineering. This is broadly consistent with the overall national pattern. It does differ slightly from the pattern in Québec, where there were proportionately more individuals with a background in business. In Alberta, there was a slightly greater share of individuals with a science background.

What this trend means for Ontario

If Ontario is to successfully develop its innovation system, investment in education at all levels, including life-long learning, must be a priority. A strong commitment to life-long learning programs would benefit not only the majority of Ontarians without post-secondary qualifications, but also those seeking to improve their skills so that they can keep pace with the constant changes that characterize an innovative economy.

Source: Statistics Canada, 1996 census, Nation Tables, special tabulations

6. Graduates in Science, Engineering and Business

Why is this important?

A sufficient supply of graduates in science, engineering and business helps to fuel the innovative capabilities of the economy. The greater the supply of such graduates, the wider the pool of talent available to meet the needs of a high-technology economy. Conversely, if the domestic supply of such graduates is inadequate, the innovative capacity of the economy will be reduced unless the shortfall can be overcome through the immigration of highly qualified personnel from elsewhere.

How well is Ontario performing?

Of the 4,863 graduates in engineering and applied sciences in Ontario in 1998, nearly six per cent obtained a Doctorate, 16 per cent received a Master's degree and 78 per cent a Bachelor's degree. A similar percentage breakout applied to the 3,961 graduates in mathematics and the physical sciences. Of the 54,000 graduates who received a Bachelor's degree in Ontario in 1998, just under 7,000, or 13 per cent, received that degree in engineering and applied sciences, or mathematics and the physical sciences.

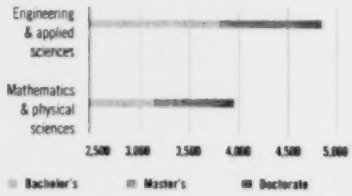
Though the trend of relatively few graduates in the sciences is a common one across the country, Ontario trails the other large provinces in the percentage of total Bachelor's degrees awarded in a number of specific fields. The gap is particularly large in the fields of engineering and business. Ontario only finished above the national average in the areas of mathematics and biology.

The last graph presents the trends in graduates by field over time. Some specific fields have seen sharp increases. Over the period 1994-1998, the number of graduates in computer science increased by 31 per cent from 975 to 1,279 per year. A 30 per cent increase was realized in biology (2,222 to 2,891). A smaller gain was realized in engineering (seven per cent). The largest decrease occurred in mathematics, where the number of graduates decreased by 19 per cent from 1,277 to 1,037.

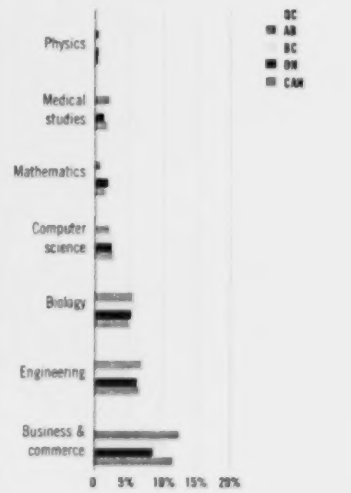
What this trend means for Ontario

Between 1994 and 1998, the number of graduates in most science fields increased in Ontario. However, in fields like computer science and engineering, the demand outstrips the supply. Initiatives, such as the recent Access to Opportunities Program, which attempt to bring government, universities and colleges and the private sector together to increase the capacity of the system to produce the required graduates, are therefore most welcome. The goal in the future must to be to maintain the positive momentum generated by such initiatives.

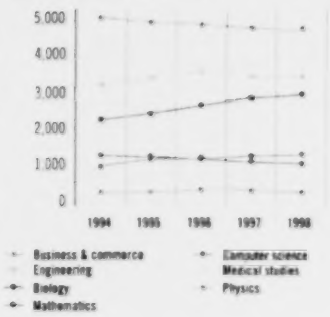
Ontario Graduates in the Natural Sciences and Engineering, 1998



Bachelor's and First Professional Degrees Awarded for Selected Fields of Study, 1998
Percentage of Total Degrees

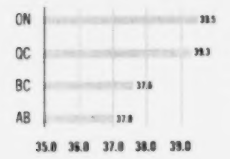


Bachelor's and First Professional Degrees Awarded in Ontario, 1994-1998

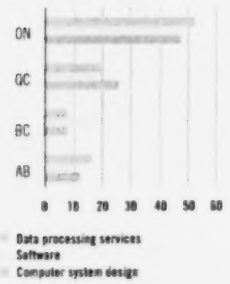


Source: Statistics Canada, *Education in Canada* (1996-2000 editions) Catalogue No. 81-229-XIB

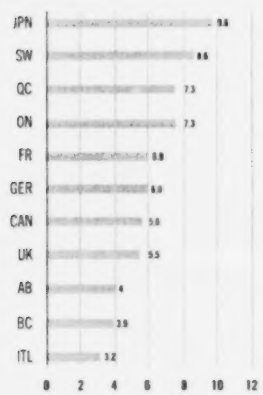
Experienced Labour Force in Management, Business, Sciences and Engineering, 1996
Percentage of Workforce



Employment in Selected Knowledge-Intensive Sectors, 1998
Percentage of National Total



Researchers per 1,000 Persons in the Labour Force, Selected Jurisdictions, 1998



7. Knowledge Jobs

Employment in knowledge-intensive sectors

Why is this important?

A skilled and experienced labour force is vital to the development and diffusion of technology. Indeed, the lack of such human capital can be one of the greatest impediments to innovation, since much of the important knowledge required in the innovation process is not easily reproduced, remaining embodied in people's skills, experiences and education. Three indicators are examined: the experienced workforce in management, business and the sciences; employment in key knowledge-intensive sectors; and the number of researchers per capita.

How well is Ontario performing?

Over 39 per cent of the Ontario labour force was employed in the broad occupational fields of management, business, sciences and engineering, and health in 1996. This placed Ontario at the top of the national rankings, just ahead of Québec.

The data processing, software and computer-system design sectors play a key role in the dissemination of innovations to other firms. Ontario was home to approximately half of the national total of these highly skilled employees.

Ontario also ranks well internationally in the proportion of researchers in its labour force. Among the major provinces, Ontario and Québec led the way with 7.3 researchers per 1,000 persons in the labour force in 1998. This also placed Ontario in the same league as such R&D-intensive economies as Japan and Sweden.

Despite the skilled workforce in the province, Ontario employers still face significant challenges in finding skilled personnel. For example, in Statistics Canada's 1999 Survey of Innovation, 65.9 per cent of innovative manufacturing firms in Ontario agreed that it was difficult to find highly qualified staff and workers, as compared to the national figure of 63.4 per cent.

What this trend means for Ontario

Ontario's highly skilled workforce provides firms in the province with a strong competitive advantage as they attempt to exploit opportunities in the knowledge-based economy. Skill shortages do exist, however. The public and private sectors will have to work together to address such shortages in the future.

Source: Statistics Canada Census 1996, Nation Tables; Annual Survey of Software Development and Computer Services, 1998; Estimates of Research and Development Personnel in Canada, 1979 to 1999.

8. R&D Expenditures

Why is this important?

Expenditures on research and development represent a critical input into the innovation system and are thus a key indicator of the health of that system.

How well is Ontario performing?

In comparison with other Canadian provinces, Ontario performs well. Our level of R&D expenditures per capita of $690 in 1999 was the highest in the country. And our ratio of R&D expenditures to provincial gross domestic product of two per cent is second only to Québec.

Compared with other jurisdictions, however, our performance has room for improvement. Our ratio of R&D expenditure to gross domestic product is significantly lower than that of California, Massachusetts, Michigan or Sweden, and is only roughly comparable to that of Illinois.

Overall Ontario expenditures on R&D have risen from $4.2 billion in 1989 to $7.9 billion in 1999 (in current dollars). In 1999, nearly 69 per cent of this R&D activity was performed (though not necessarily funded) by business enterprises. In 1989, the figure was nearly 65 per cent. The higher education sector's share of this activity stood at 27 per cent in 1999, down slightly from the nearly 28 per cent share it had 1989. The federal and provincial governments accounted for the remaining activity.

What this trend means for Ontario

Investments in R&D are the driving force behind an innovative economy. Not only do such investments lead to the development of new products, processes and services, they also allow us to recognize and exploit useful knowledge developed elsewhere. Such investments also allow us to train the highly qualified personnel needed for a knowledge-based economy.

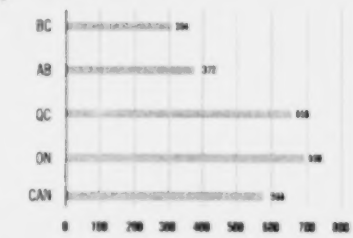
The main players in the Ontario innovation system clearly recognize the importance of such investments. For example, several significant initiatives designed to bolster Ontario's research infrastructure have been announced in the private and public sectors in recent years. However, to keep pace with some of the other leading technological jurisdictions in North America, these commitments will need to be sustained and even enhanced in the future.

Sources: Statistics Canada; National Science Foundation; U.S. Dept. of Commerce, Bureau of Economic Analysis

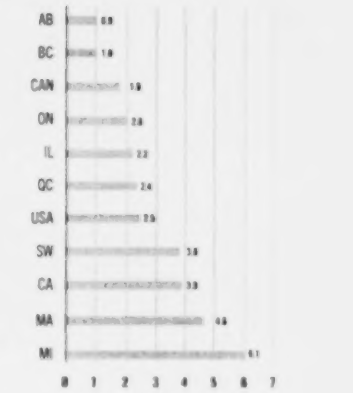
Note: The R&D expenditure figures for Ontario and Quebec exclude spending by the federal government in the National Capital Region

R&D Infrastructure

Gross Expenditures on R&D per Capita, Selected Provinces, 1999
$



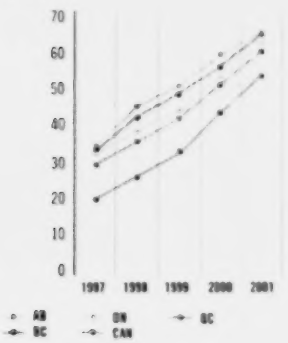
R&D Expenditures as a Percentage of Gross Domestic Product for Jurisdictions, 1999



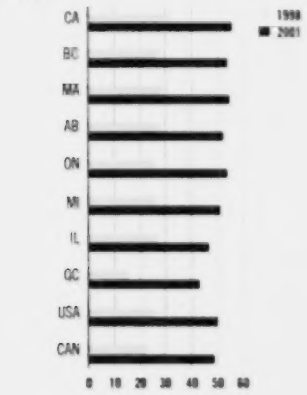
Ontario R&D Expenditures by Performing Sector, 1989-1999
$ Millions

9. Household Internet Use

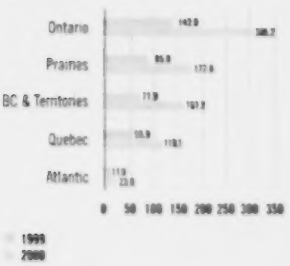
Internet Access Rates from Any Location, by Province, 1997-2001
Per Cent



Use of the Internet from the Home, Selected Jurisdictions, 1998-2001
Per Cent



Subscribers to High-Speed Internet by Cable, 1999-2000
Thousands of Subscribers



Why is this important?

Many argue that widespread access to the Internet is critical to ensure that individuals and households can participate fully in the knowledge-based economy and to prevent the emergence of a "digital divide" in our society.

How well is Ontario performing?

The percentage of Ontario households that have accessed the Internet from any location, be it the home, school, workplace, public libraries or other locations, has increased from 33 per cent in 1997 to nearly 64 per cent in 2001. This performance exceeds the national average, but trails that of Alberta and British Columbia.

In the percentage of households that can access the Internet from home, Ontario is again ahead of the Canadian national average, though it slightly trails British Columbia and some key U.S. jurisdictions, including California and Massachusetts.

Access to high-speed Internet services will become increasingly important in the future. Cable Internet services are one of the principal means of securing such services. In Canada, the western provinces lead the way in cable Internet access, having accounted for 42.8 per cent of all cable Internet subscribers in 1999, as compared with a 33.7 per cent share of all household Internet subscribers. Ontario households had fewer high-speed Internet subscribers; it accounted for slightly less than 39 per cent of the national cable Internet subscriber base, as compared with a 41 per cent share of all household Internet subscribers.

Preliminary numbers from Statistics Canada indicate that the number of high-speed cable Internet subscribers in Ontario reached 506,093 in 2001, or 36.5 per cent of the national total of 1,387,816 subscribers.

What this trend means for Ontario

Ontario households perform well in accessing the Internet, though we are somewhat behind such jurisdictions as Alberta, British Columbia, California and Massachusetts. A majority of Ontario households has now achieved some level of Internet access, though not necessarily directly from the home. The next challenge will be to ensure widespread access to high-speed Internet services across all regions of the province.

Source: Statistics Canada, *Service Bulletin: Broadcast and Telecommunications*, Vol. 11 No. 3 (August 2001), CANSIM II, Table 3580002; *The Daily* (July 25, 2002); U.S. Dept. of Commerce, National Telecommunications and Information Administration, "A Nation Online: How Americans are Expanding Their Use of the Internet" (Feb. 2002); "Falling Through the Net II: Toward Digital Inclusion," (October, 2000); "Falling Through the Net III: Defining the Digital Divide" (July 1999)

10. Venture Capital Investments

Why is this important?

Venture capital investments are an important indicator of an economy's ability to commercialize new ideas and grow new companies. An economy with a high level of venture capital investment is more likely to be an innovative economy.

How well is Ontario performing?

Ontario leads the rest of Canada both in terms of the absolute amount of venture capital invested (over $2.2 billion in 2001) as well as the amount invested per capita ($191 per person in 2001).

Ontario's investments in venture capital are dwarfed, both in absolute and per capita terms, by jurisdictions such as California and Massachusetts. However, the level of investment is quite competitive with that found in jurisdictions like Michigan and Illinois.

Ontario's venture capital markets also held up better than those in the U.S. during the downturn of 2001. As a result, Ontario was able to close the gap with some of the leading U.S. states. Nevertheless, our per capita venture capital investment still doesn't match the U.S. average.

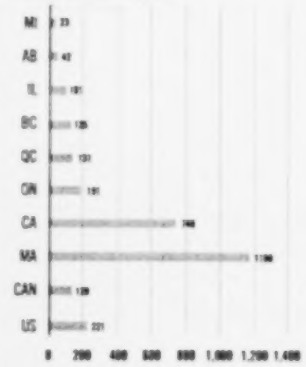
Venture capital investments in Ontario tend to be highly concentrated in the broad information technology sector, particularly in the subsectors of communications and networking, semiconductors and other IT and software.

What this trend means for Ontario

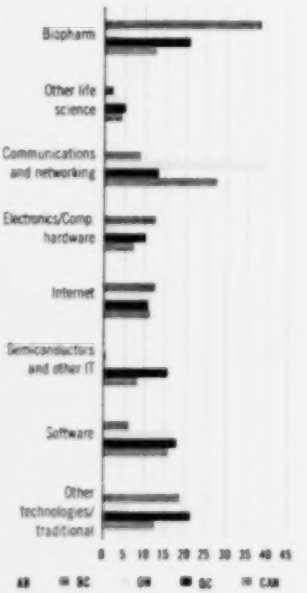
The growth in the availability of venture capital experienced in the late 1990s, along with the growth in the number of young companies seeking such investments, is a positive sign for Ontario's future. Sustaining that growth into the future will be a key policy challenge.

Jurisdiction	Total Investments Can$ Millions		Per Capita Can$ Millions	
	2000	2001	2000	2001
AB	243	128	81	42
BC	540	512	133	125
QC	1,380	968	187	131
ON	3,036	2,266	260	191
MI	486.1	229	49	23
IL	3,150	1,258	254	101
CA	65,852	25,818	1,944	748
MA	15,440	7,526	2,432	1,180
CAN	5,337	3,980	173	128
U.S.	157,297	62,495	559	221

Venture Capital Investments Per Capita, Selected Jurisdictions, 2001



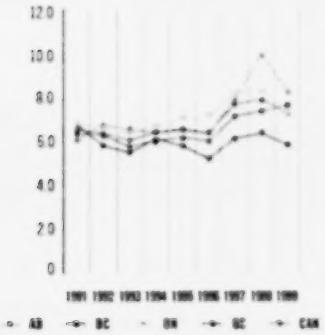
Distribution of Venture Capital Investments by Sector and Province, 2001
Sector Investments as a Per Cent of Total VC Investments



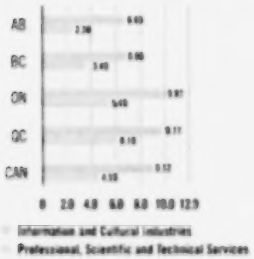
Sources: Canadian Venture Capital data from Macdonald & Associates, as of 2002 Q2. U.S. venture capital statistics from NVCA 2002 Yearbook (PricewaterhouseCoopers/Venture Economics/National Venture Capital Association Moneytree Survey)
U.S. population figures from http://www.census.gov/prod/2001pubs/statab/sec01.pdf
Canadian population statistics from Statistics Canada
Canada-U.S. exchange rate from www.bankofcanada.ca/en/exchange.htm

11. Investments in Machinery and Equipment

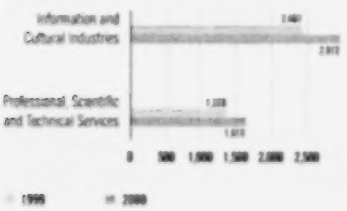
Total Investments in Machinery and Equipment as a Percentage of Provincial Gross Domestic Product, 1991-1999



Investment in Machinery and Equipment, Selected Industries, as a Percentage of Total Investments in Machinery and Equipment, 2000



Total Investments in Machinery and Equipment, Selected Industries, for Ontario 1999-2000
$ Millions



Why is this important?

One of the ways in which firms can improve their level of productivity and innovative performance is by acquiring, and successfully incorporating, new technologies and processes developed elsewhere. The pace at which new technologies are being adopted can be partially measured by examining levels of investment in machinery and equipment.

How well is Ontario performing?

Throughout the 1990s, Ontario's total investment in machinery and equipment, expressed as a percentage of provincial GDP, matched or exceeded the national average. In five of those years, Ontario led the nation. In 1999, Ontario's investments in machinery and equipment amounted to 7.4 per cent of the provincial GDP, or $29.5 billion.

When expressed as a percentage of total provincial investments in machinery and equipment, Ontario leads the country in terms of investments in information and cultural industries, and finishes second to Québec in the field of professional, scientific and technical services.

The growth rate of investments in these sectors in Ontario between 1999 and 2000 was quite impressive. Investments in machinery and equipment for the information and cultural industries sector increased by 23.5 per cent, while the comparable figure for professional, scientific and technical services was 21.3 per cent.

What this trend means for Ontario

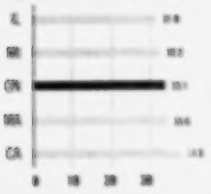
Ideally, firms boost their innovative performance both through internal R&D investments and through investment in new technologies and processes. Our earlier example of R&D expenditures demonstrated that, while Ontario performs well in the Canadian context, its performance trails behind that of some of its major international competitors. However, the strong levels of investment in machinery and equipment depicted here can help to offset, at least in part, shortcomings in internal R&D expenditures. These levels of investment will have to be sustained into the future if Ontario wishes to remain an innovative economy.

Source: Statistics Canada, CANSIM database

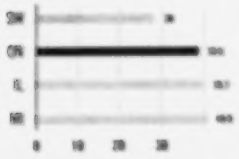
Incentives for Commercialization and Growth

12. Tax Rates

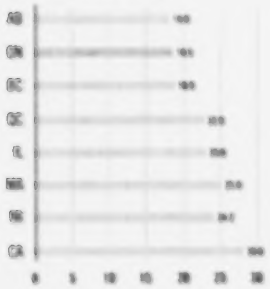
Comparison of Ontario and U.S. Personal Income Tax Rates, 2001
Marginal Tax Rate (Per Cent)



Comparison of Corporate Income Tax Rates, Selected Jurisdictions, 2002
General CIT rate (Per Cent)



Marginal Individual Capital Gains Tax Rates, Selected Jurisdictions, 2001-2002
Marginal Tax Rate (Per Cent)



Why is this important?

Since capital and labour are mobile, a jurisdiction with above-average rates of personal and corporate income tax and capital gains tax runs the risk of significant outflows of both investment and skilled labour. This in turn may lead to a lower standard of living for people in the abandoned jurisdiction, since the jobs lost will likely have been in high technology and high paying.

How well is Ontario performing?

In 1995, Ontario's personal income tax rate was one of the highest in North America. Since that time, personal income tax rates have been significantly reduced. As a result of these cuts, an individual earning $60,000 a year in Ontario now faces a combined federal/provincial marginal tax rate of 33.1 per cent. This rate is squarely in the middle of the pack of North American jurisdictions and heading lower. It is also far lower than the rates found in most European countries.

Similar significant cuts are being made to corporate income taxes. As a result of tax cuts to date, Ontario's general combined corporate income tax rate is now below the rate of any of the neighbouring U.S. states. Once the government's corporate income tax cuts have been fully implemented, Ontario will have the lowest general combined corporate income tax rate of any province or U.S. state.

Small high-technology firms are often the originators of key technological breakthroughs. They are also always in search of capital. Competitive capital gains tax rates, which reward such entrepreneurial activity, can act as a key incentive for promoting innovative activity. Recent moves to reduce capital gains rates mean that Ontario's combined federal/provincial individual capital gains tax rate is now lower than that in any major U.S. state. In Canada, only Alberta has a lower combined rate.

What this trend means for Ontario

Innovative firms and highly skilled individuals take a number of factors into account when they decide where they want to locate. Some of these additional factors are dealt with elsewhere in this report. Nonetheless, an attractive tax regime is clearly an important factor. Ontario's tax rates are now highly competitive on all fronts. These competitive rates, along with an attractive R&D tax incentive structure (see Indicator #13), make Ontario a highly desirable location for innovative firms and skilled individuals from a tax perspective.

13. Relative Attractiveness of R&D Tax Incentives

Measuring the relative attractiveness of the R&D tax regime in selected jurisdictions, 1998

Why is this important?

Though the decision to invest in R&D depends on a number of factors, there is little doubt that the relative attractiveness of a jurisdiction as a location for such investments is enhanced if it possesses an attractive R&D tax regime.

The B-index is an indicator that measures the impact that a tax system has on private sector decisions to invest in R&D. It specifically measures the present value of before-tax income required to cover the cost of an R&D investment, as well as applicable income taxes. The lower the B-index, the more attractive the R&D tax incentive structure.

How well is Ontario performing?

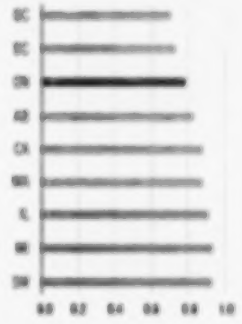
When compared to the other major Canadian provinces, we see that Ontario possessed the third most attractive tax incentive regime for large manufacturing firms in 1998, after Québec and British Columbia. In the case of the incentives available to small manufacturing firms, Ontario performed somewhat better, finishing second to Québec.

No distinction was made between the tax treatment given to small and large firms in the foreign jurisdictions examined. Nevertheless, we can see that Ontario possesses a lower B-index score than do these foreign jurisdictions, even when using the more conservative measure of the tax treatment given to large firms.

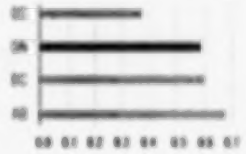
What this trend means for Ontario

Tax-based incentives for research and development constitute one important tool that a jurisdiction can use to build its science and technology infrastructure. As the data show, Ontario possesses one of the most attractive R&D tax regimes in the world. Such incentives need to be constantly reviewed, however, to ensure that the province retains a tax regime that is not only competitive with those found in other jurisdictions, but continues to achieve the original intent of the policy and does not introduce undue complexity into the tax system.

B-index Score (Canada-Large Firms Only; U.S. states, Sweden-All Firms), 1998

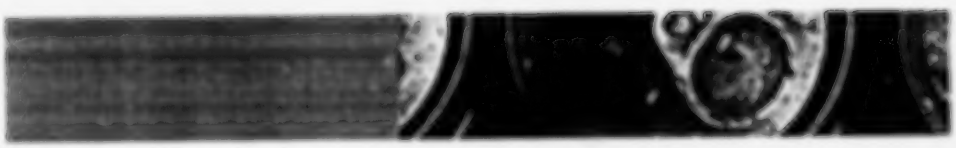


B-index Score (Small Manufacturing Firms), 1998



Source: Measuring the Attractiveness of R&D Tax Incentives: Canada and Major Industrial Countries. A report prepared by Foreign Affairs and International Trade Canada, the Ontario Investment Service and Statistics Canada by Jacek Warda, Conference Board of Canada.

Note: The lower the B-index score, the more attractive the R&D tax incentive structure.

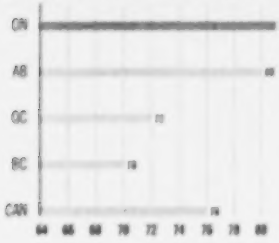


Innovation Performance

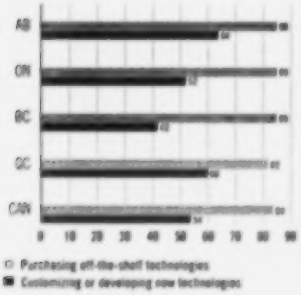
14. Technology Adoption Rates

Adoption rates of advanced technologies in the manufacturing sector, 1998

Percentage of Manufacturing Firms Using at Least One Advanced Technology, 1998



Approach to the Introduction of Advanced Technologies, 1998
Per Cent



Why is this important?

The ability to integrate new advanced technologies into production processes is a key sign of how innovative a firm is.

How well is Ontario performing?

Eighty-one per cent of Ontario manufacturing firms in 1998 reported that they had introduced at least one advanced technology out of a list of 26 provided. This placed Ontario slightly ahead of Alberta (80 per cent) and somewhat further in front of Québec (72 per cent) and British Columbia (70 per cent). The technologies listed covered six functional areas: design and engineering; processing, fabrication and assembly; automated material handling; inspection; network communications; and integration and control.

Also of interest is the strategy a firm follows in introducing technologies. Does it simply purchase technologies off the shelf or does it possess the ability to customize existing technologies or develop new ones?

Purchasing off-the-shelf technologies was clearly the more popular strategy among those firms that introduced at least one advanced manufacturing technology in 1998. There was little variation on this score by province, with the provincial percentages ranging from 82 to 86 per cent. Provincial variations did exist, however, when it came to the customization or development of new technologies. Alberta firms were the most likely to follow this strategy (64 per cent), followed by Québec (60 per cent), Ontario (52 per cent) and British Columbia (42 per cent).

What this trend means for Ontario

These results show that Ontario manufacturing firms are quick to adopt new advanced technologies, though they may be somewhat lacking in the ability to customize existing technologies or develop brand new ones.

A high rate of uptake of advanced technologies is a trend that must continue in order to ensure the competitiveness of Ontario's manufacturing sector. This will require a sustained effort to reduce the obstacles to technology adoption, whether they take the form of financial or human resource constraints, managerial limitations or a lack of external support services or information.

Source: Statistics Canada, *Survey of Advanced Technologies in Canadian Manufacturing, 1998* (Special provincial tabulations)

15. Patterns of Innovative and Collaborative Behaviour Among Manufacturing Firms

Why is this important?

To be successful in a knowledge-based economy, firms must be able to generate and use knowledge to develop significantly improved products, processes and services. Increasingly, firms must collaborate with universities, provincial research institutions, suppliers, customers and even competitors to carry out such developmental work.

How well is Ontario performing?

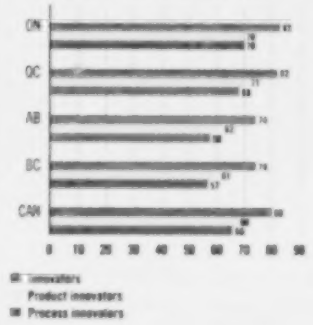
Eighty-three per cent of Ontario's manufacturing firms reported that they were innovative in 1999, where being innovative was defined as having introduced a new or significantly improved product or process in the three previous years. This places Ontario above the national average and on a par with Québec (82 per cent). It also places Ontario ahead of Alberta and British Columbia, where 74 per cent of firms reported that they were innovative. Very similar patterns emerge when we look at product and process innovations separately.

Innovative firms in Ontario are also more likely to collaborate with others in developing new or improved products and processes. Forty per cent of innovative firms in Ontario reported such collaborative arrangements, which places Ontario ahead of British Columbia (34 per cent), Québec (28 per cent) and Alberta (27 per cent).

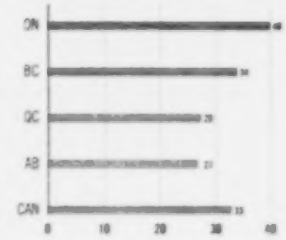
What this trend means for Ontario

Ontario manufacturing firms have shown themselves to be among the innovation leaders in Canada in the development of new and improved products, processes and services. They have also demonstrated a willingness to collaborate with a variety of partners in order to promote innovative developments. These positive patterns of behaviour will have to persist and be strengthened in the future in order to maintain Ontario's competitive position.

Percentage of Manufacturing Firms Introducing an Innovation During the Period 1997-1999



Percentage of Innovative Manufacturing Firms with Co-operative and Collaborative Arrangements During the Period 1997-1999



Source: Statistics Canada, *Survey of Innovation 1999* (Special provincial tabulations)

16. Bibliometrics

A bibliometric assessment of Ontario's science system

Why is this important?

Ontario's science base is a crucial component of its innovation system, contributing knowledge, skills and new ideas to both the public and the private sectors. The importance of the science base will continue to grow as new technology-intensive industries make increasing use of scientific knowledge. A widely used approach for measuring scientific performance is bibliometric analysis, which examines the number of scientific publications produced by a region's research institutions.

How well is Ontario performing?

Though Ontario is responsible for the greatest share of scientific publications in the country, on a per capita basis it came second to Alberta in 1995, with 1,053 publications per million of the population. Of these publications, over 60 per cent were written by university researchers, followed by hospital researchers with 16 per cent. The federal government was also a significant contributor, with 13 per cent of the total.

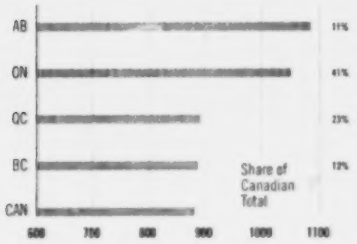
The specialization index estimates Ontario's presence in selected disciplines. Calculated as the ratio of articles in a specific discipline written in Ontario to those in Canada, the index shows Ontario specializing in six disciplines: physics, chemistry, earth sciences, applied science and engineering and, to a lesser extent, clinical medicine and mathematics.

What this trend means for Ontario

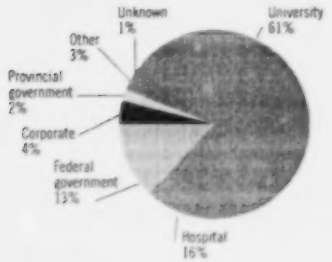
Ontario must continue to support its science system if it is to improve its position in leading technology industries. Many firms in these leading sectors rely increasingly on scientific discoveries and knowledge for their success. Much of this knowledge originates at universities and other public research institutions. Therefore support should not only be directed to applied research, but also to basic research and to the promotion of science-industry interactions.

Scientific Publications per Capita, 1995

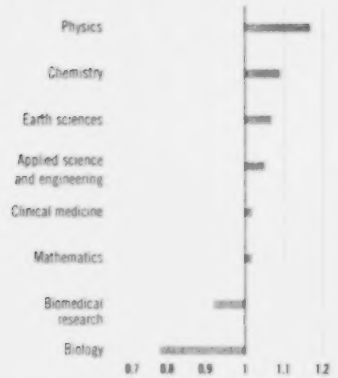
Number of Publications Per Million Population



Distribution of Scientific Publications by Sector, Ontario, 1995



Specialization Index*, Ontario, 1995



*Specialization Index = (% of articles in Ontario in discipline X)/(% of articles in Canada in discipline X)

Source: B. Godin, Y. Gingras and L. Davignon. *Knowledge Flows in Canada as Measured by Bibliometrics.* Observatoire des sciences et des technologies (CIRST). Working paper prepared for Statistics Canada (Catalogue No. 88F0006XPB No. 10). October 1998.

17. Ontario University Research Performance

Why is this important?

Evaluating the performance of universities is difficult, given the challenges of constructing valid, comparable indicators across such a heterogeneous group of institutions. Nevertheless, some form of metric is desirable in order to determine where our universities stand in relation to universities in other provinces.

Bibliometric indicators are useful since they track the most important university research output—scientific publications. A bibliometric approach also makes it possible to measure the quantity of research generated as well as the quality of that research.

How well is Ontario performing?

The first chart provides a ranking of the top 10 universities in the country in terms of publications per professor in the natural, biomedical and engineering fields. Five Ontario universities reached the top 10, with the University of Toronto finishing second on this measure. Both Guelph and McMaster improved their position as compared to 1995.

The quality of the research generated by researchers at a given university can be measured by examining the "impact factor" of the journals in which their work is published. The impact factor measures the number of citations a journal receives over a specified time.

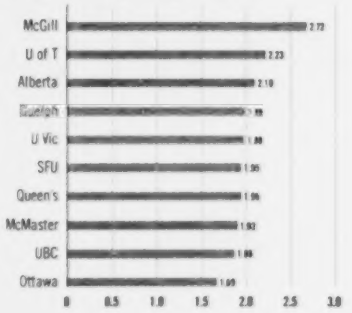
The Observatoire des sciences et des technologies has constructed a "relative weighted impact factor" (RWIF), a synthetic index that combines the impact factors across eight different scientific fields into one score. Scores above one indicate a score above the national average. Eleven universities reported a score of 1.0 or greater, with three of these being from Ontario.

International research collaborations improves the quality of scientific research by exposing domestically based researchers to scientific research generated elsewhere. The last chart shows which Canadian universities have been most active internationally as measured by the share of total scientific publications co-authored with a foreign researcher. Carleton University leads the way, while three other Ontario universities, York, McMaster and Waterloo, made the top 10 list.

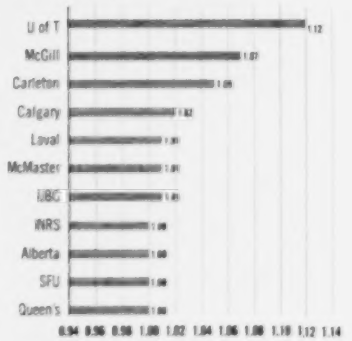
What this trend means for Ontario

Ontario's research-intensive universities demonstrate solid performance both in terms of the quality and quantity of research produced. They are also well connected to the international scientific community. All partners in the innovation system will have to work together to ensure that these levels of performance are maintained and improved upon in the future.

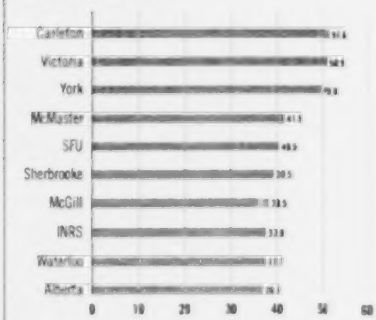
Publications per Professor in the Natural, Biomedical and Engineering Fields, 1998



Relative Weighted Impact Factor (RWIF) in the Natural, Biomedical and Engineering Fields, 1998*



Percentage of Papers Involving International Collaboration in the Natural, Biomedical and Engineering Fields, 1998

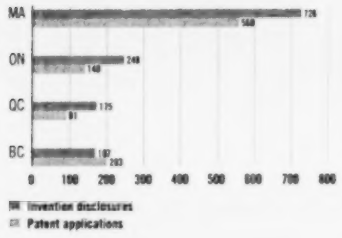


Sources: Observatoire des sciences et des technologies (OST), *Canadian Universities' Performance in Research 2000 Edition*
* Breakouts by specific field can be found in Appendix A.

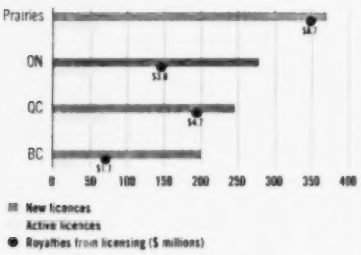
18. University Idea Generation and Commercialization

Inventions, patents, licensing and spin-off companies at Ontario universities

University Patents and Inventions, Selected Jurisdictions, 1998-1999



University Technology Licences, 1999



Spin-off Companies: Canadian Universities, 1999

Why is this important?

Ontario's universities play a significant role in the province's innovation system, not just as providers of education, but also as important sources of innovative ideas. The number of invention disclosures and patent applications, the extent of technology licensing, together with the number of companies spun off from research activities, are among the indicators that can be used to measure the universities' capacity to contribute to the province's base of commercially viable knowledge.

How well is Ontario performing?

The contribution made by Ontario universities to Canada's commercialization of intellectual property has been modest, given the high level of research activity in the province. Strong in the number of invention disclosures, spin-off companies and technology licences generated, Ontario fares less well in terms of generating royalty earnings from technology licences and in the ratio of spin-off companies to income from sponsored research.

What this trend means for Ontario

As innovations become more reliant on scientific research, the importance of universities to the regional economy will continue to grow. It is, therefore, vital for Ontario's universities to continue to expand their role in commercializing their intellectual property and supporting the early phases of innovation through sound policy.

Ontario is well on its way to harnessing this potential through programs such as the Ontario Centres of Excellence, which bridge the gap between university research and the market through directed research, commercialization of technology and the training of workers.

Sources: Statistics Canada, *Survey of Intellectual Property Commercialization in the Higher Education Sector*, 1999 (including special tabulations); Association of University Technology Managers, *AUTM Licensing Survey 1999*; Massachusetts Technology Collaborative, *Index of the Massachusetts Innovation Economy 2000*

19. Patents

Why is this important?

The granting of a patent is one key measure of a successful R&D program. Besides being a vehicle for protecting intellectual property rights, patents also serve as a means of diffusing information regarding new products and processes. Patent statistics are an important indicator of the level of innovative activity in the economy.

How well is Ontario performing?

Over the period 1980 to 1999, Ontario produced just less than half (48 per cent) of all of the inventions granted to Canada by the United States Patent and Trademark Office (USPTO). Québec received 19 per cent, while British Columbia received 11 per cent and Alberta 9 per cent.

Ontario also ranks first in the number of institutional inventions per capita, finishing above the national average, a distinction it shares with Québec. Both Alberta and British Columbia, however, reported higher growth rates than Ontario on this measure over time.

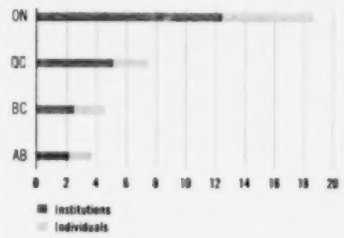
Ontario holds a 46 per cent share of the national total of inventions created by individuals. On a per capita basis, Ontario generated 38 individual inventions per million inhabitants in 1999, placing the province slightly behind British Columbia and Alberta. Once again, the two western provinces demonstrated higher growth rates over time.

The one measure where Ontario does not shine involves the province's balance of trade in intellectual property. Though institutional and individual inventors in the province were responsible for 18,539 inventions, the ownership rights for only 15,360 of these patents were held in the province, a net loss of 3,179 inventions. Only Québec reported holding more patents than the number of inventions contributed. This is largely due to the fact that Nortel Networks lists Montréal as the ownership location for its laboratories.

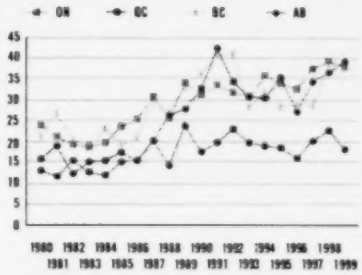
What this trend means for Ontario

These statistics show that Ontario's institutional and individual inventors are among the leaders in the country when it comes to realizing inventions granted by USPTO. As Godin et al., note, this reflects in part the impact of "agglomeration economies," that is, the economic benefits arising from the clustering of activities. However, Ontario faces some key challenges in improving both the growth rate in the level of inventions per capita and its balance of technological exchange.

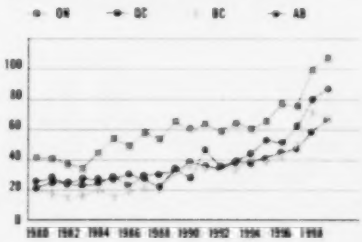
Individual and Institutional inventions, Selected Provinces, (1980-1999)
Number (in Thousands)



Individual Inventions by Province per Million Population (1980-1999)



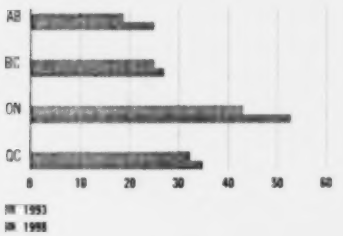
Individual Inventions by Province per Million Population (1980-1999)



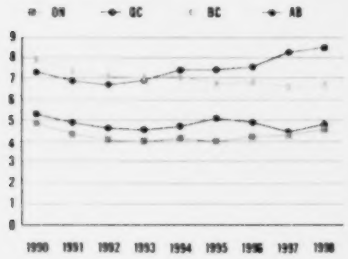
Source: Observatoire des Sciences et des technologies (USTPO). (Preliminary data)
A more complete reporting of the results is available in Benoit Godin, Christian Dore and Eric Archambault, "Measuring Invention in Canada: The Geographic Dimension," Working Paper No. 1 of the Project on the Development of Innovation Indicators (July 2001)

20. New Business Starts

New Business Starts
Number of New Businesses, in Thousands



New Businesses per Capita
New Businesses per 1,000 People



New Businesses by Sector, 1998

Why is this important?

An environment conducive to innovation is one that also encourages risk-taking, particularly in the form of new business ventures. In such an environment, both start-ups and business failures are expected as innovation transforms the structure of the economy.

The number of new business starts is also an indication of the health of Ontario's business climate. If entrepreneurs were hampered by such factors as a shortage of qualified workers or poor access to capital, new businesses could not readily establish themselves.

How is Ontario performing?

In Ontario, 52,153 new business starts were registered with the Canada Customs and Revenue Agency in 1998, an increase of 22.5 per cent from 1993. Despite such a strong performance, Ontario trails Alberta and British Columbia when new business starts are compared on a per capita basis, a trend that has been consistent throughout the past decade. However, business starts have been increasing since 1995, and by 1998, were approaching the pre-recession 1990 level of 4.9 new business starts per 1,000 people.

What this trend means for Ontario

Ontario's relatively low level of new business starts is in part a reflection of the presence of a greater number of large firms. Though such businesses are important to Ontario's global competitiveness, the province could consider enhancing support to new businesses, especially in high-growth industries. Incubator programs and entrepreneurship training are two examples of possible means of support.

Source: Statistics Canada, *Employment Dynamics* (Cat. No. 61F0020XCB)

Note: The data are compiled from Canada Customs and Revenue Agency payroll deduction files; numbers do not include non-employer businesses.

21. Initial Public Offerings

The number of market flotations of Ontario firms

Why is this important?

As an important step in the growth of new technology firms, initial public offerings (IPOs) can provide several insights into the health of Ontario's innovation system.

For many burgeoning technology companies, a successful market flotation is a crucial source of capital that allows them to bring their technology to market, acquire other firms or further their R&D. And, with investors confident in their growth prospects, these firms are typically the growth leaders. IPOs also allow venture capitalists to free up their capital for reinvestment in the next wave of innovative young companies.

The prospect of an IPO may also be an important incentive for attracting highly skilled individuals to a firm during the early stages of its development, which highlights the importance of having healthy levels of IPO activity in Ontario.

How is Ontario performing?

Despite a 14 per cent decline in the number of IPOs between 1998 and 2000, the average value of capital raised for each flotation jumped from $83 million in 1998 to $121 million in 2000.
Over 40 per cent of the IPOs completed on Canadian exchanges in 2000 were in Ontario.

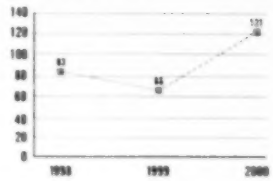
Ontario compares favourably with several American states, showing more IPOs than Massachusetts, Illinois and Michigan. However, in terms of total value, Ontario falls behind Massachusetts.

What this trend means for Ontario

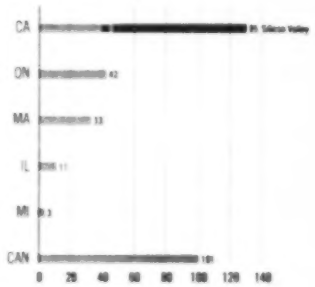
Ontario's promising IPO activity, along with its developing venture capital market (see Indicator #10), suggests that the province's financial environment is indeed developing in a manner that is conducive to a prospering innovation economy.

IPO Activity in Ontario
Number of IPOs

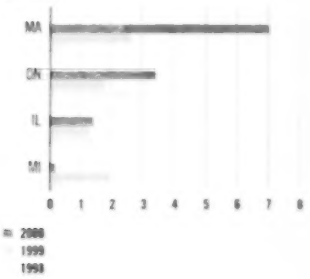
IPO Activity in Ontario
Average Value ($ Millions)



Number of IPOs, 2000



Value of IPOs
$ Billions



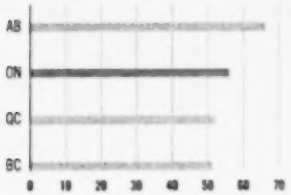
2000
1999
1998

Sources: Ontario Ministry of Enterprise, Opportunity and Innovation, Hale and Dorr, PricewaterhouseCoopers, *Survey of IPOs in Canada 2000*, Joint Ventures Silicon Valley Network, 2001 Index of Silicon Valley, Bank of Canada

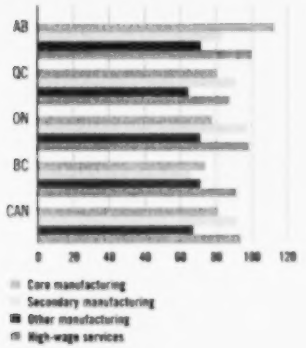
22. Labour Productivity Performance

GDP per job in selected industry sectors, 1996-1997

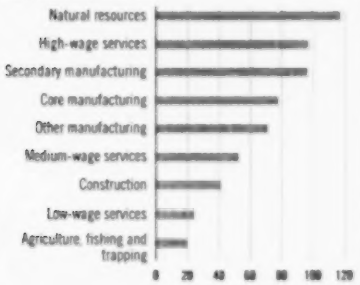
Average Gross Domestic Product per Job, by Province, 1996-1997
GDP per Job ($ Thousands)



Sectoral Productivity in the Innovative Sectors, 1996-1997
GDP per Job ($ Thousands)



Sectoral Productivity in Ontario, 1996-1997
GDP per Job ($ Thousands)



Why is this important?

Companies that continually innovate and use advanced technologies improve their competitiveness. This is reflected in labour productivity statistics, as measured by GDP per worker across sectors. Sustained growth in labour productivity is the underlying source of gains in living standards, which is why initiatives to improve productivity performance are so important.

How is Ontario performing?

Differences in labour productivity reflect variations in both labour efficiency and capital intensity. When comparing overall labour productivity levels across provinces, it is also necessary to take into account differences in industrial composition, as well as differences in productive efficiency within sectors.

With an average GDP per job of $56,000 in 1996-1997, Ontario's business sector productivity trailed Alberta's by some $10,000. In fact, Alberta was the only province that reported both a more favourable industrial mix and higher levels of productivity efficiency than Ontario.

This largely reflects the impact of Alberta's highly capital-intensive oil and gas industry on productivity in the natural resource sector. However, the effect was also felt in the more innovative core manufacturing ($34,000 gap) and high-wage service ($2,000 gap) sectors. Core manufacturing encompasses electronic products, machinery, pharmaceuticals, chemical products and refined petroleum. The high-wage service sector includes wholesale, storage, utilities, finance and pipelines. However, Ontario leads in the area of secondary manufacturing.

The most productive sector in Ontario was natural resources ($118,300). It was followed by high-wage services ($98,200). The innovative core manufacturing sector, which produces innovations or technologies for self-use and for use in other sectors, was only the fourth most productive sector, trailing behind secondary manufacturing.

What this trend means for Ontario

Within Canada, Ontario has achieved solid overall levels of labour productivity performance thanks to its favourable industrial mix and the level of productive efficiency achieved in individual sectors.

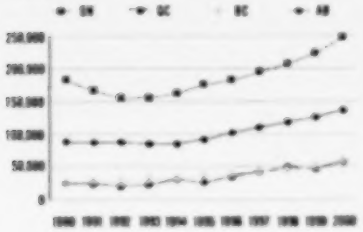
Investments in innovation and technology will be needed to sustain labour productivity growth in the future.

Source: Statistics Canada, *The Daily*, August 24, 2001. See Appendix A for sector definitions.

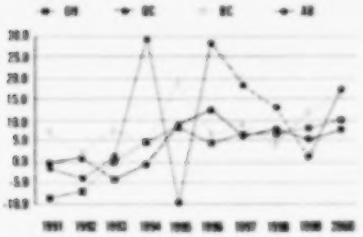
Innovation Outcomes

23. Employment Growth in High-Technology Fields

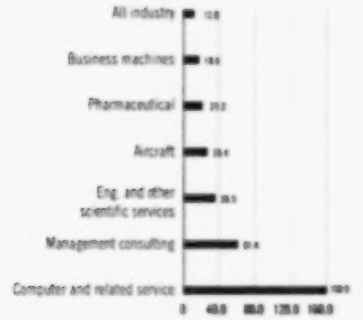
Total Employment in High-Technology Industries, 1990-2000



Employment Growth in High-Technology Sectors, 1991-2000
Per Cent



Percentage Increase in Total Employment for Selected R&D Intensive Industries in Ontario, 1995-2000



Why is this important?

Employment growth in the high-tech sectors of the economy is one measure of how well the innovation system is performing.

How well is Ontario performing?

The number of Ontarians employed in high-technology sectors (the definition can be found in Appendix A) has increased from just less than 188,000 in 1990 to 251,420 in 2000, an overall increase of 33.9 per cent.

Despite this growth, Ontario's share of the national total has declined from 52 per cent in 1990 to 46 per cent in 2000. Ontario's growth rate has not matched those achieved in the other major provinces. The growth rates in Alberta and British Columbia have been particularly strong, approximately 124 per cent for both provinces between 1990 and 2000. British Columbia was also the only province that reported a positive growth rate in high-technology jobs every year during the decade. This discrepancy in growth rates may simply reflect the fact that Ontario's high-technology industry is larger and more mature than those found in the other provinces.

However, impressive growth rates have been achieved in Ontario in specific high-tech sectors, particularly in computer and related services. As the last graph shows, all of these R&D-intensive sectors reported employment growth rates higher than the rate for all industries as a whole over the period 1995 to 2000.

Moreover, the rates of growth in employment appear to be correlated with the overall level of R&D intensity for the sectors in question. For example, the R&D intensity of the business machines sector (measured as intramural R&D expenditures as a percentage of revenues) was 2.3 per cent in 1998. This was matched with an employment growth rate of 18.6 per cent. Compare this with computer and related services, where an R&D intensity figure of 20.8 per cent was matched with an employment growth rate of 160.9 per cent! This positive link between the R&D intensity of a sector and its employment growth rate largely holds for the other sectors listed as well.

What this trend means for Ontario

The evidence presented here suggests the existence of a plausible connection between the level of R&D investment and employment growth. The connection is not straightforward, however. It depends on the efficiency with which the innovation system transforms investments in R&D into new products and processes. The challenge for all sectors in Ontario is to enhance the efficiency of the innovation system to promote the growth of good, high-paying jobs.

Sources: B.C. Stats, *Profile of the British Columbia High Technology Sector, 2000 Edition*; Statistics Canada, Industrial Research and Development, 2000, interdivisional (special Ontario tabulations) Cat. No. 88-202-XIB; CANSIM II database. (see Appendix A for information on the methods and data series used)

24. Average Pay per Worker

A comparison of average weekly earnings of all employees, including overtime

Why is this important?

Average weekly earnings across different industry sectors not only reflect productivity levels, but also point to where growth is occurring. Companies that produce more efficiently or provide innovative, high-demand goods and services can afford to pay their workers more. And, in a knowledge-based economy, the ability to pay higher wages to attract and retain highly skilled workers can be crucial to a company's success. Higher average earnings can have negative implications if they are not matched by higher productivity performance and thus raise costs to the point where they may make companies uncompetitive.

How is Ontario performing?

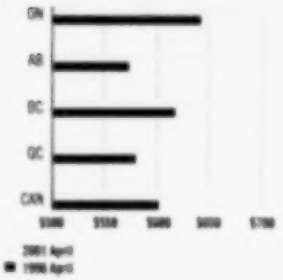
Ontario's workers continue to earn more on average across all industries than do their Canadian counterparts. In April 2001, this lead amounted to seven per cent more than the Canadian average and 4.2 per cent more than the next highest-paid province, Alberta. This wage gap between Ontario and the rest of Canada has remained roughly consistent since 1996.

The province also shows a remarkably consistent lead in weekly earnings in several key industries, such as software, innovation services, computer and communications hardware and in such long-standing industries as mining, finance and insurance.

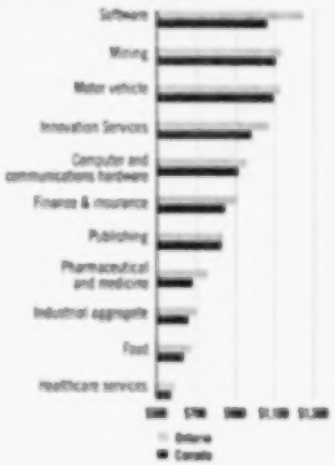
What this trend means for Ontario

The significant wage gap between R&D-intensive industries and the overall industry average only reinforces the importance of knowledge industries to Ontario's economy, particularly in their capacity to retain highly skilled workers with both attractive opportunities and salaries. But as more traditional industries such as mining demonstrate, high wages are not just the preserve of the newer industries. By investing in new technologies and innovation, both old and new industries can continue to provide well-paying jobs by becoming more efficient and competitive.

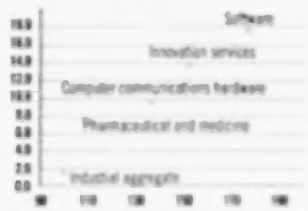
Average Weekly Earnings
(For All Industries, Seasonally Adjusted)



Average Weekly Earnings of All Employees, Selected Industries, April 2001



Average Ontario Pay, Selected R&D-intensive Industries
R&D expenditures as a percentage of revenues

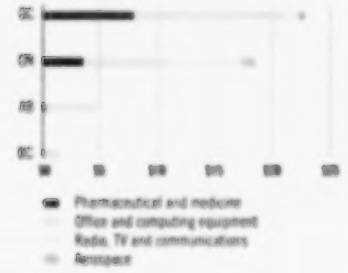


Sources: Statistics Canada, *Industrial Research and Development 2001 Intentions*, Cat No. 88-202-XIB (Canada, Ontario tabulations); CANSIM II (Matrices 17042, 17048)

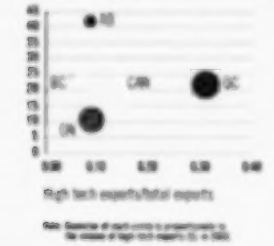
25. High-Technology Exports

Ontario's export performance in high-tech manufacturing

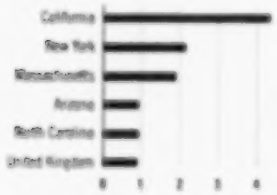
High-Technology Exports, 2000
Billions



Positioning of Ontario's High-Technology Exports
Average Growth in High-Tech Exports, 1996-2000, (Per Cent)



Leading Destinations of Ontario High-technology Exports, 2000
Can $ Billions



Why is this important?

High-technology exports are an important indicator of a region's capacity to innovate and maintain its technological advantage in world markets. They also bring rewards to the leaders and owners of technological innovations who have successfully capitalized on their innovation efforts, creating new world markets or expanding their share of existing ones. The definition of high-technology industries adopted here is consistent with that currently in use by the OECD and includes the following: aerospace; office and computing equipment; pharmaceuticals and radio, TV and communication equipment.

How well is Ontario performing?

Although Canada's largest overall exporter in 2000, Ontario came second to Québec in high-technology exports, with 38 per cent of the national total of $48.3 billion. Such performance is partly explained by the fact that in the latter half of the last decade, Ontario experienced the slowest average annual growth in high-tech exports at 10 per cent, well behind Alberta's 42 per cent and less than half of Québec's 22 per cent. In terms of its ratio of high-technology exports to total exports in the country, Ontario, with a ratio of under 0.1, again trails Québec (0.3) by a large margin. California is the main recipient of Ontario's high-technology exports, followed by New York and Massachusetts. The United Kingdom is the largest destination outside of the United States, receiving $700 million in exports in 2000.

What this means for Ontario

Ontario's performance in high-tech exports is in part a reflection of an economy heavily reliant on motor vehicle manufacturing. This predominance of car making, however, does not explain the below-average growth in high-technology exports. For Ontario's high-technology industrial development base to expand, its research and development base must also expand, building upon its technological strengths in such leading growth industries as information technologies, photonics and biotechnology.

Source:

Note: High-technology industries included in this study are based on 5 SIC categories. SIC 3721 - Aircraft and Aircraft Parts Industry; SIC 3761 - Record Player, Radio and Television Receiver Industry; SIC 3763 - Communication and Other Electronic Equipment Industries; SIC 3769 - Office, Store and Business Machine Industries; SIC 3790 - Pharmaceutical and Medicine Industry.

26. GDP per Capita

A look at Ontario's gross domestic product on a per capita basis

Why is this important?

Gross domestic product (GDP) per capita is a useful and widely used indicator for measuring and comparing economic performance. Defined as the total annual value of goods and services produced per person, the indicator provides an approximate measure of a region's overall productivity and economic efficiency. GDP per capita has its limitations, since its does not capture such factors as distribution of income, health and education outcomes and the state of the environment.

How is Ontario performing?

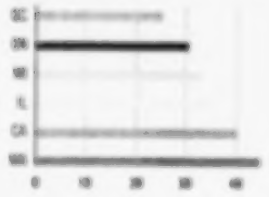
Though Ontario is one of the most prosperous jurisdictions in the world outside the United States, it has been losing ground to a number of neighbouring American jurisdictions. A recent analysis by the Institute for Competitiveness and Prosperity found that Ontario ranked 14th on GDP per capita out of the 16 jurisdictions in the U.S. and Canada with populations over six million. Ontario's per capita income of $30,420 was far below the median level of $35,300 reported for these jurisdictions.

This productivity gap is likely to widen further, given Ontario's slower productivity growth rate. Indeed, over the past decade, Ontario (along with Quebec) has experienced poor productivity growth, well below its American counterparts, particularly Massachusetts and Michigan.

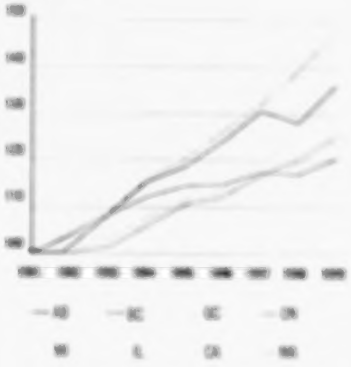
What this trend means for Ontario

If Ontario is to improve productivity, more investment in new technologies and innovation will be required, particularly in mature industries, which have in the past been responsible for creating much of the province's existing wealth.

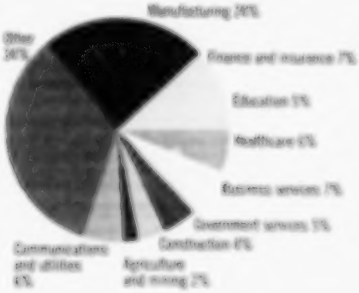
GDP per Capita, Ontario and Selected North American Jurisdictions, 2000
US$ Thousands
Note: Dollar values calculated using purchasing power parities



GDP per Capita,
Percentage change



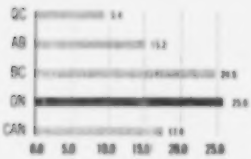
Percentage Distribution of Ontario GDP by Selected Industries, 1999



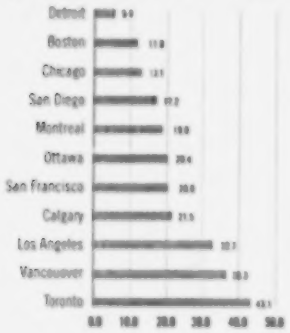
Sources: Institute for Competitiveness and Prosperity, Statistics Canada and Bureau of Economic Analysis

27. Cultural Diversity

Immigrant Population as a Share of Total Population for Canada and Selected Provinces, 1996



Foreign-Born* Population as a Share of the Total Population, Selected North American Cities



Why is this important?

In a knowledge-based economy, firms are attracted to regions that have large pools of highly skilled individuals. But what factors attract these individuals to a region? Recent work in the United States by Richard Florida suggests that one key factor is diversity. Cities or regions that demonstrate an inclusive attitude towards diverse populations provide the type of creative environment in which these highly talented individuals can thrive. The diversity of a city or region can be measured, in part, by examining the cultural diversity of its population.

How well is Ontario performing?

According to the 1996 Census, just over 25 per cent of the Ontario population was composed of immigrants to Canada. By this measure, Ontario had the most culturally diverse population in the country, slightly ahead of British Columbia.

Of greater importance in the context of the arguments made above is the cultural diversity of the major city/regions in a given jurisdiction. Our second graph compares the percentage of foreign-born individuals in selected North American cities. By this measure, Toronto is the most culturally diverse city of the group selected. Just over 43 per cent of the population of Toronto in 1996 was foreign-born. This places Toronto well ahead of a number of major American cities. These cross-border comparisons should be treated with caution, however, given the six-year gap between the U.S. and Canadian census data.

What this trend means for Ontario

The population of Ontario in general, and Toronto in particular, is very diverse culturally. This demonstrates a level of tolerance that is highly attractive to the creative individuals who are the driving force behind the knowledge-based economy. Though other factors contribute to quality of life, in terms of diversity and tolerance, Ontario is well positioned to attract such creative individuals into the future.

Sources: Statistics Canada, Statistical Profile of Canadian Communities (1996 census data)
U.S. Census Bureau (1990 census data)
* The definition of 'foreign-born population employed differs somewhat between Canadian and U.S. cities. Appendix A provides further details.

28. Crime Rates

Rates of violent, property and youth crime

Why is this important?

The safety of communities is an important indicator of quality of life. Regions where people feel that their families and property are safe from crime are more attractive for investment than regions that suffer from higher crime rates.

How well is Ontario performing?

Over the period from 1990 to 2000, property crime rates in Ontario have dropped 33 per cent, from just over 5,000 incidents per 100,000 of the population to just under 3,400 incidents. The decline in violent crime rates was less dramatic at just over eight per cent, from 968 incidents per 100,000 of the population in 1990 to 887 incidents in 2000.

In 2000, Ontario recorded the second-lowest violent crime rate among the major provinces, after Quebec, and the lowest property crime rate. Property crime rates were down 5.3 per cent from 1999, though violent crime rates did edge up by 4.1 per cent.

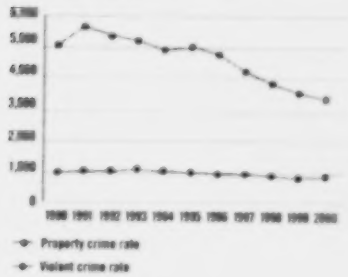
Among the four major provinces, Ontario reported the highest rate of serious violent crime incidents per 100,000 of the youth population (ages 12 to 17) in the year 2000. It also reported the second-highest youth property crime rate, after Alberta. However, the absolute number of youth charged with property crime offences has been on a relatively steady downward path, from 30,167 charges recorded in 1991 to 16,860 in 2000.

What this trend means for Ontario

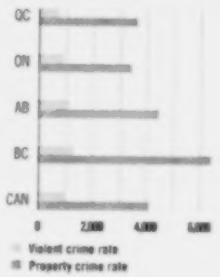
Care must be taken in interpreting such statistics, given the range of factors that can have an impact upon the rate at which criminal charges are laid, including better detection methods by the police, enhanced public awareness, experimentation with alternatives to the formal justice system for youth crime, etc. Nevertheless, the numbers indicate that Ontario's property crime rate is on a positive downward path and that violent crime rates remain fairly static, though the overall number of youth charged is higher than in the other major provinces.

Sources: Statistics Canada, Canadian Centre for Justice Statistics, "Crime Statistics in Canada, 2000," Juristat, Vol. 21 no. 8, (July 2001) Catalogue no. 85-002, Uniform Crime Reporting Survey (UCR)

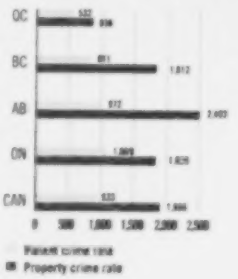
Property and Violent Crime Rates, Ontario, 1990-2000
Rate per 100,000 Population



Selected Criminal Code Incidents for Canada and Selected Provinces, 2000
Rate per 100,000 of the Youth Population



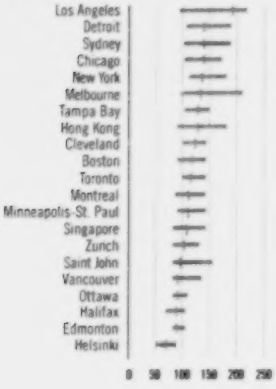
Youths Charged with Selected Criminal Code Incidents for Canada and Selected Provinces, 2000
Rate per 100,000 of the Youth Population



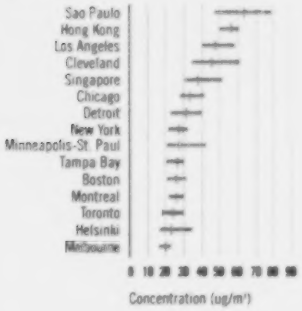
29. Air Quality

Ozone and particulate matter levels for Toronto and other selected cities, 1990-1999

10-Year Range of Maximum One-Hour Ozone Levels in Selected Cities Around the World (1990-1999)



10-Year Range of Composite Annual Mean for PM_{10} Concentrations in Selected Cities Around the World (1999)



Ranking of Metropolitan Areas in the Great Lakes Basin Area According to Criteria Pollutant Levels (1990-1999)

Metropolitan Area	O_3	PM_{10}	NO_2	CO	SO_2	Total Score	Overall Ranking
Chicago	4	4	3	1	3	15	3
Cleveland	3	5	5	5	5	23	5
Detroit	5	3	2	3	4	17	4
Minneapolis -St. Paul	1	2	1	4	1	9	1
Toronto	2	1	4	2	2	11	2

Individual rankings are summed for each metropolitan area to determine an overall score

Why is this important?

Regions that offer a high quality of life stand a better chance of attracting and retaining both innovative firms and highly skilled individuals. A healthy environment is one factor that contributes to human health and a high quality of life. Air quality is the most visible barometer of the health of a region's environment, though not the only one.

How well is Ontario performing?

Comparative measures of air quality are generally best done at the level of individual cities. The Ontario Ministry of the Environment recently conducted such an analysis, which compared the ambient air quality of Toronto against that of major world cities.

The two main components of smog are ground-level ozone and inhalable particles. Over the period from 1990 to1999, Toronto ranked 11th-best out of 21 cities for maximum one-hour ozone concentrations. Nationally, Toronto recorded the highest ozone levels, Edmonton the lowest. In terms of the 10-year range in composite annual mean PM_{10} levels, Toronto reported the third-best results internationally, and was slightly better than Montreal nationally.

A composite indicator was also constructed, comparing Toronto to four other cities in the Great Lakes Basin area, based on the concentration level of five key pollutants (ozone, PM_{10}, nitrogen dioxide, carbon monoxide and sulphur dioxide) measured in the ambient air over a 10-year period (1990-1999). By this measure, Toronto finished second behind Minneapolis-St. Paul in terms of best overall air quality.

What this trend means for Ontario

Toronto's air quality compares quite well with that of other major metropolitan areas. However, complacency on air quality must be avoided. Southern Ontario continues to suffer from high levels of ozone, as well as PM_{10} and its precursors, in part because of the long-range transport of these pollutants from the mid-western United States. Efforts to reduce the level of such pollutants, both domestically and in collaboration with our American neighbours, must therefore continue.

Source: Ontario Ministry of the Environment, Air Quality in Ontario, 1999.

Note: Caution must be exercised in assessing these results due to differences in monitoring methods, siting procedures, the topographical features of the cities selected, etc.

30. Health of Ontarians

A comparison of selected health indicators

Why is this important?

Ontario's economic health depends on a healthy population that is able to learn and work effectively and efficiently. Smoking less, exercising more and maintaining a healthy weight are among the factors that contribute to health and well-being. The health index comprises four such factors, each weighted equally: the proportion of the population who do not smoke; the proportion who are physically active; the proportion who have an acceptable weight according to international Body Mass Index (BMI) standards and the proportion of the population who have not taken days off for a disability in the two weeks prior to being surveyed by Health Canada.*

How is Ontario performing?

In 1998-1999, Ontario showed a marked improvement in the health index rating, up 2.5 per cent from 1994-1995 to the same level as Alberta and Quebec, but well below that of British Columbia. Its ranking is largely attributable to a low level of physical activity and a substantial portion of the population (52 per cent) whose BMI is above the acceptable range of 18.5 to 24.9. Encouragingly, far fewer Ontarians now smoke every day than was the case in previous years. Of the smokers in 1994-1995, approximately 18 per cent had quit by 1998-1999. This places Ontario second to British Columbia in having the least number of daily smokers.

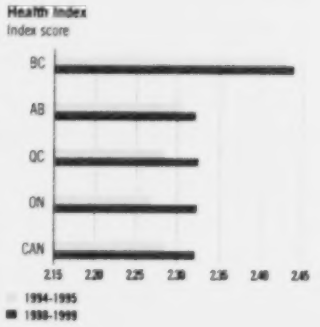
What this trend means for Ontario

The positive trends in the overall health of Ontarians noted above will need to continue in future, since a healthy population is one key ingredient of a highly productive, growing economy.

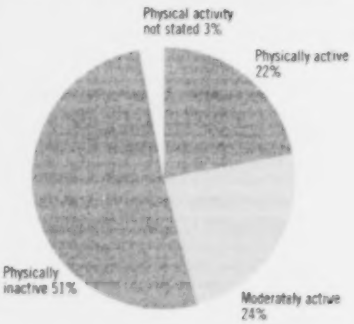
Source: Statistics Canada, Health Indicators, Catalogue 82-221-XIE.

* Health Index = $\sum$ of the proportion of the population (with BMI of 18.5-24.9, with no 2 wk. disability days, who are physically active, who are non-smokers)

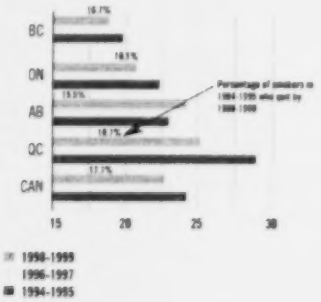
Quality of Life Indicators



Leisure Time Physical Activity in Ontario, 1998-1999



Smokers and Quitters
Percentage of the Population that Smokes



Appendix A:
Data Sources and Methodological Notes

1. Coverage of Science and Technology in the Press

Searches were carried out on the headlines and lead paragraphs of stories. The information providers for the searches were Dow Jones for the *National Post, Globe and Mail* and *Toronto Star*; Canadian NewsDisc for the *Ottawa Citizen* and CEDROM/Newscan for the *Kitchener-Waterloo Record* and *London Free Press*. Because the indexing and search technology was different for each provider, the search results were not uniformly consistent across topics; however, the differences are not likely to be significant.

Because the searches only covered headlines and lead paragraphs, it was sometimes difficult to determine the relevance of articles. This problem occurred most often in the broad "science" and "technology" searches (e.g. a story on "science fiction" might be picked up by the "science" search).

The term GMO refers to genetically modified organisms. The search on this term also includes articles containing the term "genetically modified."

Items the search would miss include adjective forms (e.g. scientific, technological) or short forms (e.g. biotech).

In general, no restrictions were placed on the searches, in terms of the geographic scope of the coverage.

2. Ontario Student Performance in Science

In the first diagram (page 17), the lines represent the 95 per cent confidence interval around a jurisdiction's mean score. This means that we are 95 per cent sure that the true mean score for a jurisdiction lies within this interval. If the intervals for two jurisdictions overlap, as is the case among Ontario and all the U.S. states except Michigan, we can conclude that there is no statistically significant difference among these jurisdictions' mean scores.

In December 2001, the OECD released results from its Program for International Student Assessment. This project assessed the performance of 15-year-old students in OECD member countries in reading, mathematics and science. The major focus of the first round was on reading skills. However, results were obtained on science literacy.

A more detailed examination of the Canadian results, including inter-provincial comparisons, was released simultaneously in a report sponsored by Statistics Canada, Human Resources and Development Canada and the Council of Ministers of Education entitled *Measuring Up: The Performance of Canada's Youth in Reading, Mathematics and Science*. The inter-provincial results in science from this study are quite similar to those found in the TIMSS report. Alberta and Québec both reported science results that were significantly above the national average, while British Columbia and Ontario reported results that were in the same range as the national average.

Another recent report from Statistics Canada, using data from the 1994-1995 TIMSS study, found that interest in science and mathematics declines between grades 4 and 8 and continues to fall during high school. This pattern is more prevalent in Canada and the United States than in the other countries participating in the TIMSS survey. (See Statistics Canada, *The Daily*, January 4, 2002.)

3. Percentage of Teachers with Backgrounds in Science and Technology

The following fields of specialization in the census were combined to form the "Humanities and Social Science" category in the first chart for this indicator:

- Fine and applied arts
- Humanities and related fields
- Social sciences and related fields
- Commerce, management and business administration

The "Natural Sciences and Engineering" category was formed from the following fields of specialization:

- Agricultural and biological sciences and technologies
- Engineering and applied sciences
- Engineering and applied science, technologies and trades
- Health professions, sciences and technologies
- Mathematics and physical sciences

The "Educational, Recreational and Counselling Services" category is a stand-alone category.

4. Enrolment in Secondary School Science Courses

In the second and third graphs (page 19), the biology, chemistry and physics categories were constructed by adding together enrolments for both the standard course offerings (e.g. SCH for chemistry) and applied courses (e.g. SCA for applied chemistry). The "other" category is composed of courses in such fields as environmental science, geology and science in society. Like the courses in the more traditional scientific disciplines, these courses, such as the ones offered in geology, can serve as useful preparation for eventual specialized study in university. This category also includes courses that explore the impact of science and technology on everyday life, for those students who are not planning to specialize in science after graduation.

5. Educational Attainment of the Workforce

The first and third graphs (page 22), report on the highest degrees achieved by all people 15 years of age and over. They are drawn from a special tabulation from the 1996 Census.

The second graph summarizes the population 20 years and over, with university certificates or degrees, not attending school in sciences, engineering and business. This covers the following major fields:

- Commerce, management and business administration
- Agricultural and biological sciences or technologies
- Engineering and applied sciences
- Engineering and applied science technologies and trades
- Health professions, sciences and technologies
- Mathematics and physical sciences

Data for the second figure was drawn from the 1996 Census Nation Tables at
http://www.statcan.ca/english/census96/apr14/educ3.htm

6. Graduates in Science, Engineering and Business

Data from the 1996 to 2000 editions of Statistics Canada's *Education in Canada*, Catalogue. No. 81-229-XIB.

7. Knowledge Jobs

The first figure, using data from the 1996 Census, reports on the total labour force employed in the following broad occupational areas:

- Management occupations
- Business, finance and administrative occupations
- Natural and applied sciences and related occupations
- Health occupations

The data can be found in the Nation Tables on the Statistics Canada website at http://www.statcan.ca/english/census96/mar17/occupa/indus.htm. These tables cover the labour force 15 years of age and over by broad occupational categories and major groups, using the 1991 Standard Occupational Classification. The data are based on a 20 per cent sample from the census.

For the second figure, the categories of data processing services, software and computer system design are based on the new North American Industrial Classification System (NAICS). The data summarize results from the *Annual Survey of Software Development and Computer Services, 1998* (Cat No. 63-222-XPB).

In the third figure, the occupational classification of researchers (scientist/engineer) encompasses those engaged in the conception or creation of new knowledge, products, processes, methods and systems. This level also includes managers and administrators engaged in the planning and management of the scientific and technical aspects of a researcher's work. They are usually equal in rank to the researchers and are often former or part-time researchers themselves. Postgraduate students, in particular those performing significant amounts of R&D, are included in this category.

This category does not include technicians or equivalent staff or support staff.

The figures for France, Italy and Sweden are for 1997. The national figures for these countries, and also those for Canada and the United Kingdom, are likely underestimated due to rounding. The Japanese figure is likely overestimated, since it is not based on full-time equivalent personnel. The data are drawn from *Estimates of Research and Development Personnel in Canada, 1979 to 1999e* (Science, Innovation and Electronic Information Division, Working Paper #9, 2001, Catalogue Number 88F0006XIB01009).

8. R&D Expenditures

The R&D figures reported for the Canadian provinces, as well as the Canadian and Swedish national figures, are drawn from two Statistics Canada publications:

Service Bulletin, Science Statistics Vol. 25, no. 8 "Total Spending on Research and Development in Canada, 1990 to 2001e, and Provinces, 1990 to 1999" (November 2001) Catalogue 88-001-XPB; and

Estimates of Canadian Research and Development Expenditures (GERD), Canada, 1989 to 2000e, and by Province 1989 to 1998. (Science, Innovation and Electronic Information Division, Working Paper #1 2001 Catalogue 88F0006XIB01001).

U.S. figures are from the NSF InfoBrief entitled *Half the Nation's R&D Concentrated in Six States* (June 2002).

The GERD-to-GDP ratio is influenced both by a jurisdiction's economic structure and the propensity to perform R&D in particular sectors. The relative importance of these factors varies from jurisdiction to jurisdiction. Canada has traditionally reported a lower GERD-to-GDP ratio than other major industrial countries, in part due to greater defence R&D expenditures in those nations.

9. Household Internet Use

In the first graph, "regular" use households were those that responded yes to this question: "In a typical month, does anyone in the household use the Internet from any location?"

The graph on high-speed Internet by cable reports on the number of subscribers as of August 31, 1999, and August 31, 2000. The figures quoted for Ontario in the text are to August 31, 2001.

10. Venture Capital Investments

The currency conversion rates used are as follows:

2001: US$1 equals Can$1.548416
2000: US$1 equals Can$1.485202

The annual average exchange rates are from the Bank of Canada (http//www.bankofcanada.ca/en/exchange.html).

U.S. population figures are from http://eire.census.gov/popest/data/states/populartables/table4.php

Canadian population statistics are from Statistics Canada.

U.S. venture capital statistics are from NVCA 2002 Yearbook (PricewaterhouseCoopers/Venture Economics/National Venture Capital Association Moneytree Survey).

Canadian venture capital data is from Macdonald and Associates, as revised in 2002 Q2. These figures exclude venture capital investments by Canadian venture funds outside the country from the national statistics.

11. Investments in Machinery and Equipment

The total investments in machinery and equipment reported encompass total non-residential investments in both the public and private sectors. Capital investments for construction or repair are excluded. The level of investment in machinery and equipment as a percentage of GDP was calculated using current dollar figures. The following data from the CANSIM 1 database were extracted to construct this indicator:

National and Provincial Gross Domestic Product (expenditure-based):

Matrix 9006: Series D24082
Matrix 9014: Series D24193
Matrix 9019: Series D24363
Matrix 9023: Series D24499
Matrix 9024: Series D24533

Investments in Machinery and Equipment:

Matrix 11500: Series D877150, D877059
Matrix 11511: Series D878708
Matrix 11524: Series D880138, D880019, D880040
Matrix 11525: Series D880475, D880356, D880377
Matrix 11528: Series D881218, D881099, D881120
Matrix 11529: Series D881576, D881457, D881478

12. Tax Rates

The data source for the first figure is Ernst and Young, 2001, as reported in the Ontario Ministry of Finance, *2001 Budget*, "Paper C: Tax Cuts: Keeping Promises, Creating Opportunities," page 81.

Data for the second figure is from the Ontario Ministry of Finance *2002 Budget*, "Paper C: Ontario's Records on Tax Cuts," page 81. It should be noted that Michigan has a value-added single business tax. Its CIT equivalent is shown for comparative purposes.

The Canadian data in the third figure are drawn from PricewaterhouseCoopers, *Tax Facts and Figures for Individuals and Corporations 2002*, page 3. The figures are for the $63,354 federal bracket. The U.S. figures are from the American Council for Capital Formation, Centre for Policy Research Special Report, "Double Whammy for U.S. Investors: Federal and State Capital Gains Tax Rates High" (May 2001), page 2. The U.S. figures are for a family with $60,000 in annual income.

Comparisons of tax rates from different jurisdictions should always be treated with caution, given the different definitions that jurisdictions have of the tax base (be it for personal or corporate income or capital gains) to which such rates are applied.

13. Relative Attractiveness of R&D Incentives

This publication can be accessed on the Statistics Canada web site as Working Paper #10 for 1999 from the Science, Innovation and Electronic Information Division at:

http://www.statcan.ca/cgi-bin/downpub/listpub.cgi?catno=88F0006XIB

14. Technology Adoption Rates

Statistics Canada has conducted four surveys of advanced manufacturing (in 1987, 1989, 1993 and 1998). The 1998 survey asked firms to indicate whether they used, or planned to use in the following two years, 26 advanced technologies. These technologies were divided into six functional groups: design and engineering; processing, fabrication and assembly; automated material handling; inspection; network communications and integration and control. Though these are the same functional groups as used in the earlier surveys, roughly a third of the specific technologies listed in 1998 were new additions to those found in the previous surveys.

15. Patterns of Innovative and Collaborative Behaviour Among Manufacturing Firms

In Statistics Canada's 1999 Survey of Innovation, an innovative firm was defined as one that had offered, in the previous three years, a new or significantly improved product, good or service to its clients.

Co-operative and collaborative arrangements were those that involved the firm in active participation in joint projects with other firms or organizations in order to develop new or significantly improved products, goods, services and/or production or manufacturing processes. The contracting-out of work that did not involve active participation did not constitute collaborative or co-operative behaviour.

Provincial estimates from the 1999 survey were recently published as Working Paper #13 (2001) from the Science, Innovation and Electronic Information Division. This report can be accessed at:

http://www.statcan.ca/cgi-bin/downpub/listpub.cgi?catno=88F0006XIB

16. Bibliometrics

This report can be found on the Statistics Canada web site as Working Paper #10 for 1998 from the Science, Innovation and Electronic Information Division at:

http://www.statcan.ca/cgi-bin/downpub/listpub.cgi?catno=88F0006XIB

17. Ontario University Research Performance

In its report, *Canadian Universities' Performance in Research, 2000 Edition*, the Observatoire des sciences et des technologies also produced relative weighted impact scores to measure the quality of research produced by Canadian universities in eight scientific fields. The universities with the highest relative impact factor scores by field are as follows:

1.	Clinical medicine:	McGill, Laval, Toronto
2.	Biomedical research:	Toronto, Alberta, McGill, McMaster
3.	Biology:	Montréal, INRS*, Queen's
4.	Physics:	INRS*, Carleton, McGill
5.	Chemistry:	Carleton, Alberta, Queen's
6.	Earth and Space:	York, Toronto, New Brunswick
7.	Engineering:	INRS*, McMaster, Toronto
8.	Mathematics:	Toronto, McGill, McMaster

* INRS: Institut national de la recherche scientifique (Université du Québec)

18. University Idea Generation and Commercialization

Canadian universities require disclosure of inventions and discoveries made by their faculty. Universities differ, however, in how aggressively they apply this policy. Some take a passive approach and simply wait for faculty to disclose inventions, while others take a more active approach and regularly consult with researchers to determine if they have generated any new discoveries and inventions that should be disclosed. The Statistics Canada *Survey of Intellectual Property Commercialization in the Higher Education Sector* only records those patents that have been disclosed to the university.

The following points should be taken into account in examining the first chart on invention disclosures and patent applications.

The first issue deals with the data reported for Massachusetts. This data, as reported in the *Index of the Massachusetts Innovation Economy, 2001*, is drawn from the Association of University Technology Managers' annual survey of university licensing activity. Therefore the results are not strictly comparable with the provincial-level data reported in the chart as collected by Statistics Canada. Also, Massachusetts may not be a totally appropriate comparison, since both the size and research intensity of its universities leads to a concentration of research effort that virtually guarantees higher levels of inventions per researcher (or per dollar spent) than at Canadian universities.

Second, in comparing Ontario with British Columbia, one finds that British Columbia applies for more patents while disclosing fewer inventions. This could be occurring for the following reasons:

- The disclosures and applications have occurred in different years;
- Universities in British Columbia may be applying for more single patents on the same invention than is the case at Ontario universities;
- Universities in British Columbia are simply more likely to initiate patent applications either due to university policies or to the nature of technologies developed.

With regard to the third chart, it should be noted that the Statistics Canada survey only reports on spin-off companies that are formed with the assistance of the university. The propensity to resort to spin-offs as opposed to licensing activity will be influenced by such factors as the type of technology being developed, the availability of licences and general market conditions. The balance can differ widely from region to region. For example, in British Columbia, there is a clear tendency to resort to spin-offs as opposed to licences, whereas in Ontario there is a more even balance.

19. Patents

The Observatoire des science et des technologies (OST) recently acquired the databases of both the United States Patent and Trademark Office (USPTO) and the Canadian Intellectual Property Office. Utilizing a grant from the Ministère de la Recherche, de la Science et de la Technologie du Québec, the OST has recently finished standardizing and codifying the information contained on Canadian patents issued by the USPTO. This indicator is based on information from that database.

As part of the process of codifying and standardizing the USPTO data, the OST made a number of improvements to the database that overcome some of the deficiencies traditionally associated with patent data. These include:

- Utilizing data on patents granted, rather than on patent applications;
- Maintaining a clear distinction between the inventors of the patent and the owners of the patent so as to be able to measure exchanges of intellectual property as well as innovation;
- Including all inventors and patent holders when compiling patent data, as opposed to the standard practice of compiling data on the basis of the first inventor or owner listed in the patent, thus allowing for the development of statistics on co-inventorship and co-ownership;
- Distinguishing between inventions created by institutions as opposed to individuals.

20. New Business Starts

The population figures used to generate the per capita rates in the second chart for the period 1990–1998 were drawn from the following CANSIM II matrices:

Matrix 6370: Series C892268
Matrix 6372: Series C893858
Matrix 6373: Series C894176
Matrix 6376: Series C895130
Matrix 6377: Series C895448

21. Initial Public Offerings

Currency conversion rates employed in the third figure are from the Bank of Canada and are as follows:

1998: US$1 equals Can$1.4835
1999: US$1 equals Can$1.4857
2000: US$1 equals Can$1.4854

22. Labour Productivity Performance

"Core manufacturing" represents highly dynamic industries that produce innovations or technologies for self-use or use in other sectors. The category includes electronic products, machinery, pharmaceuticals, chemical products and refined petroleum. The "secondary manufacturing" sector is less innovative, in that it both uses technologies produced by other sectors and produces innovations for use in other sectors. It includes primary metals, transportation, rubber, plastic, fabricated metals and non-metallic minerals. The "other manufacturing" sector essentially absorbs technologies and innovations produced by the core and secondary manufacturing sectors. It includes tobacco, paper, beverages, textiles, printing, wood, other textiles, furniture, clothing and leather. "The high-wage services" category includes wholesalers, storage, utilities, finance and pipelines.

23. Employment Growth in High-Technology Fields

The definition of the high-technology sector employed for this indicator is based on one developed by B.C. Stats for their *Profile of the British Columbia High Technology Sector, 2001 Edition*. It is based on Standard Industrial Classification codes. Future editions of the B.C. report will make use of the North American Industrial Classification System. A weighting system is employed to determine what percentage of an industry meets the definition of high technology. In the following table a √ indicates the entire industry is included in the high-technology sector, whereas a number indicates only that proportion of the industry qualifies. More details regarding the development of the definition and the weighting scheme can be found in the 1995 paper *Defining the High-Technology/Knowledge Sector in British Columbia*.

Table A1. High-Technology Industry List

SIC	Industry	Sector	Weight
3711	Aircraft and Aircraft Parts Industry	Manufacturing	√
3351	Telecommunications Equipment Industry	Manufacturing	√
3352	Electronic Parts and Components	Manufacturing	√
3359	Other Communication and Electronic Equipment	Manufacturing	√
3361	Electronic Computing and Peripheral Equipment	Manufacturing	√
3362	Electronic Office, Store and Business Machines	Manufacturing	√
3369	Other Office, Store and Business Machines	Manufacturing	√
3372	Electrical Switchgear and Protective Equipment	Manufacturing	√
3379	Other Electrical Industrial Equipment Industries	Manufacturing	√
3761	Pharmaceutical and Medicine Industries	Manufacturing	√
3911	Indicating, Recording and Controlling Instruments	Manufacturing	√
3912	Other Instruments and Related Products	Manufacturing	√
772	Computer and Related Services	Services	√
7752	Office of Engineers	Services	√
7759	Other Scientific and Technical Services	Services	√
864	Health and Other Medical Laboratories	Services	√
3192	Construction, Mining Machinery and Materials Handling	Manufacturing	13
3198	Turbine and Mechanical Power Transmission Equipment	Manufacturing	6
3199	Other Machinery and Equipment Industries, n.e.c.*	Manufacturing	3
3271	Shipbuilding and Repair Industry	Manufacturing	11
3381	Communications and Energy Wire and Cable Industry	Manufacturing	41
3711	Industrial Inorganic Chemical Industries, n.e.c.	Manufacturing	10
3914	Musical Instrument and Sound Recording	Manufacturing	11
3999	Other Manufactured Products Industries	Manufacturing	6

*n.e.c. means "not elsewhere classified"

Because the British Columbia high-technology list was designed originally to address policy questions in the context of that province's economic structure, it clearly will contain elements that would be of less relevance in the Ontario context (e.g. shipbuilding) and exclude others of relevance to Ontario (e.g. auto-parts manufacturing). Nevertheless, it does represent the one readily available set of data that makes possible comparisons of high-technology sectors across provinces. In addition, many of the industries listed would almost certainly qualify as high technology by almost any criteria of selection.

regardless of the economic structure of a given province. This "universal" set of high-technology industries would almost certainly include the aircraft and aircraft parts industry, most of the industries listed from the information, telecommunications and computing sectors and the pharmaceutical sector.

For the third chart, a preliminary list of R&D-intensive industries was created using a special Ontario tabulation of data based on the Statistics Canada publication, *Industrial Research and Development – 2000 Intentions*. This tabulation looked at current intramural R&D expenditures as a percentage of performing company revenues, by industry. If the percentage reported for an industry was 25 per cent higher than the overall industrial average, that industry was considered to represent a potential "high-technology" industry. It should be noted that the data requested reported on the total research expenditures of Ontario-based firms. It did not specify whether those firms were actually conducting that research within Ontario. However, for the purposes of the indicator, we are assuming that whatever proportion of the research that is conducted outside of Ontario will not seriously distort the results. With the list of R&D-intensive industries in hand, we then used the data from the CANSIM II database to track employment levels in these industries where possible. The CANSIM matrices and series accessed were the following:

Matrix 4369: Series L6731S0; L6731S4; L6732A3; L6732S4; L6733T1; L6733T4; L6733T6

2a Average Pay per Worker

The industrial wages reported are all based on the North American Industrial Classification System (NAICS). For the purposes of the second and third figures, some categories were aggregated to form more inclusive industrial groupings.

The motor vehicle category encompasses motor vehicle manufacturing and motor vehicle parts manufacturing.

The computer and communications hardware category corresponds to the three-digit NAICS code for computer and electronic products manufacturing. This broad three-digit category in turn encompasses such four-digit level activities as computer and peripheral equipment manufacturing; communications equipment manufacturing; semi-conductor and other electrical components; and navigation, measuring, medical and control instrument manufacturing.

Healthcare technology includes the categories medical equipment and supplies and pharmaceutical and medicine manufacturing.

The food or food-manufacturing category encompasses fruit, vegetable preserve and specialty food manufacturing; meat product manufacturing; bakeries and tortilla manufacturing; and other food manufacturing.

Innovation services encompass architectural, engineering and related services; computer system design and related services; and management, scientific and technical consulting services.

The third figure represents an attempt to establish a concordance between the weekly pay rates (reported using NAICS codes) and R&D intensity levels (using 1980 Standard Industrial Classification codes). The R&D intensity figures are drawn from special tabulations prepared for Ontario by Statistics Canada. The national level figures can be found in *Industrial Research and Development, 2000 Intentions*.

As noted, the R&D-intensity figures are currently only reported using SIC codes. Statistics Canada hopes to switch over to using the NAICS codes for classifying industrial R&D intensity over the course of the next two years. This will improve the reliability of this indicator greatly. In the meantime, the authors of this report made an initial, and somewhat imprecise, attempt to draw concordances between the R&D intensity figures and the earnings data, as summarized in the following table.

Table A2. Concordances to Link R&D Intensity Data and Average Weekly Earnings Data for Selected Industries

Industry	R&D Intensity (SIC 1980)	Average Weekly Earnings (NAICS)	Explanatory Notes
Pharmaceutical and Medicine	Pharmaceutical and Medicine Industry (3741)	325410 (Pharmaceuticals) 339113 (Medical Equipment)	
Innovation Services	Engineering and Scientific Services (7751, 7752, 7759) Computer and Related Services (7721, 7722) Management Consulting Services (7771)	Architectural, Engineering and Related Services (5413) Computer Systems Design and Related Services (5415) Management, Scientific and Technical Consulting Services (5416)	R&D intensity calculated as a simple unweighted average of the three categories of computer and related services, engineering and scientific services, and management consulting services.
Software	Computer and Related Services (7721, 7722)	Software Publishing (5112)	Software publishing in NAICS largely concords with SIC 7721 (Computer Services). So the R&D intensity figure used encompasses far more than software publishing activities.
Computer and Communications	Telecommunications Equipment (3351) Electronic Parts and Components (3352) Other Electronic Component (3359) Business Machines (3361, 3362, 3369)	Computer and Electronic Product Manufacturing (334)	R&D intensity figure once again a simple, unweighted average of the figures from the four industry groupings listed.

Though informed by concordance tables available on the Statistics Canada web site, the pairings described do not represent a fully systematic attempt to draw all possible concordances. Some of the concordances relate a class from one classification to only part of a class from another. In other cases, not all of the possible concordances are shown. Also, no attempt has been made to weight the results by industry size.

Therefore, the results for the third graph for this indicator should be treated with caution, since it represents a crude, initial attempt to draw some rough linkages between the R&D intensity and earnings data.

The earnings data was drawn from the following CANSIM 1 matrices and series:

Matrix 17042: Series L172126; L172133; L172153; L172154; L172155; L173157; L172158; L172160; L172166; L172205; L172206; L172207; L172208; L172215; L172216; L17253; 172354; L172364; L172385; L172386; L172387

Matrix 17048: Series L173107; L173113; L173128; L173129; L173131; L173132; L173133; L173137; L173144; L173179; L173180; L173181; L173182; L173189; L173190; L173322; 173323; L173332; L173352; L173353; L173354

25. High-Technology Exports

The definition of high technology employed for this indicator differs from that employed in Indicator #23 on employment growth in high-technology industries. As noted in the text, it is more in line with definitions of the high-technology sector employed by the OECD. Employing this definition was done, in part, for pragmatic reasons, to reduce the amount of export data that had to be collected to construct the indicator. However, there is considerable overlap between the definitions used in the two indicators in terms of the major categories such as pharmaceuticals, aircraft, etc.

Following up on the point regarding the automotive sector, the Canadian auto industry, which is heavily concentrated in Ontario, has traditionally spent very little on research and development as a percentage of its revenues. In its *Industrial Research and Development 2001 Intentions*, Statistics Canada notes that current intramural expenditures on R&D by the Canadian motor vehicle industry amounted to 0.2 per cent of performing company revenues in 1999. However, some significant investments in new automotive R&D facilities have been announced within the province over the course of the past few years. In addition, innovation in the automotive sector often occurs through investments in new machinery and equipment and through the development of new manufacturing and organizational processes.

26. GDP per Capita

Data for the first graph is drawn from *Measuring Ontario's Prosperity: Developing and Economic Indicator System*, the second working paper of the Institute for Competitiveness and Prosperity, drawing on original source data from Statistics Canada and the Bureau of Economic Analysis.

The percentage distribution of Ontario's GDP by industry in the third chart is based on GDP at factor cost in constant 1992 dollars.

Data from this chart were from CANSIM 1:

Matrix 8423: Series I340750; I340758; I340760; I340762; I340785; I340787; I340792; I340794; I340795; I340801; I340802

27. Cultural Diversity

The first graph reports on the immigrant population in selected provinces from the 1996 Census. As defined by Statistics Canada, the term "immigrant population" refers to:

"...people who are, or who have been, landed immigrants in Canada. A landed immigrant is a person who has been granted the right to live in Canada permanently by immigration authorities. Some immigrants have resided in Canada for a number of years, while others are recent arrivals." (Statistics Canada, *1996 Census Directory*, page 21.)

The second graph reports upon the size of the "foreign-born" population in a series of major North American cities. Data is drawn from Statistics Canada and the U.S. Census Bureau, and it should be noted that the definition of foreign-born differs somewhat between the two agencies.

For Statistics Canada, the foreign-born population includes the immigrant population plus non-permanent residents, including refugee claimants, those holding student or employment authorizations and those admitted on Minister's permits. It also includes individuals from the non-immigrant population who, though born abroad, are Canadian citizens because their parents are Canadian. For the purposes of the second graph, the foreign-born population for the Canadian cities only includes those from the immigrant population and non-permanent residents.

In the case of the U.S. Census Bureau, "native-born" refers to those born in the 50 U.S. states, in U.S. territories abroad (including Puerto Rico) and those born abroad of American parents. All others are considered "foreign-born." Data for the American metropolitan areas are from the 1990 Census.

The data for the Canadian metropolitan regions is reported on a census metropolitan area (CMA) basis. In the case of Ottawa, the population data refers to those living in the Ontario portion of the Ottawa-Hull CMA.

The closest American equivalent to the CMA concept is a metropolitan statistical area (MSA). However, in the case of larger urban areas, the concept of a consolidated metropolitan statistical area (CMSA) is employed. A CMSA generally encompasses a central or primary metropolitan statistical area (PMSA) plus adjoining urban counties. For the purposes of second chart, the following U.S. metropolitan census groupings were employed:

Detroit PMSA
Boston PMSA
Chicago PMSA
San Diego MSA
San Francisco CMSA
Los Angeles-Long Beach CMSA

28. Crime Rates

Statistics Canada gathers crime data through the Uniform Crime Reporting (UCR) survey. The survey was developed with the co-operation and assistance of the Canadian Association of Chiefs of Police. The survey, which began in 1962, collects crime and traffic statistics reported by all police agencies in Canada. The UCR survey captures reported crimes that have been substantiated through police investigation. Further details regarding the methodology employed in this survey can be found in the source document cited in the indicator.

29. Air Quality

The following procedure was used to develop the regional air quality comparison of major cities in the Great Lakes Basin area over the 10-year period 1990-1999. Data on the range of ambient levels for the five criteria pollutants (ozone, PM_{10}, nitrogen dioxide, carbon monoxide and sulphur dioxide) were used to rank the five cities being compared. The city reporting the lowest ambient level of a particular criteria pollutant would receive a score of one, the city reporting the highest level a score of five. The scores for each of the five criteria pollutants were then summed together for each city to generate that city's aggregate score. The city with the lowest total score represents the best overall air quality, whereas the city with highest score would represent the poorest air quality in the area. The cities covered in the comparison were Chicago, Cleveland, Detroit, Minneapolis-St. Paul and Toronto.

30. Health of Ontarians

The Health Index is an aggregate score that sums together the proportion of the population that:

- does not smoke;
- has a healthy Body Mass Index (BMI);
- is physically active;
- did not report any disability days during the two weeks prior to being surveyed.